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POWER

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Research

THE recorded history of man's occupation of this planet is a tale of continuous contention, not with his environment, not with the rigors of climate and famine and disease, but with other men.

The big interests that have motivated the masses have not been as to how the work that must be done in order that all may live in health and comfort and security might be accomplished more effectively, and with less and more equal effort, but what tribe or race or creed or sovereign should hold the supremacy.

Mankind has spent its existence in war ano preparation for war, in desolating its homes until exhausted, and then in girding its loins for and dreading the next struggle. How much of the total of human toil and sacrifice and suffering has gone into these manifestations of greed and ambition, of racial hatred and religious bigotry.

The inventor of the mariner's compass did the world more good than Caesar or Alexander.

The invention and development of the art of printing has done more to emancipate the masses and aid the progress of mankind than the rise or fall of any dynasty.

The application to transportation and industry of the steam engine was of more importance to the human race than the outcome of all the wars in its history.

The invention of the cotton gin had a more profound effect upon the history of North America than the war of independence.

The development of the telegraph, the telephone, the wireless, is doing more to bring about the Brotherhood of Man than all the scheming and slaughtering of the Machiavellian emperors.

The nations of the world are even now spending billions of dollars each year in preparations for carrying out their racial or national ambitions or in guarding themselves against such aggressions.

How much are they spending on an intelligent and systematic study of those things that would really help to make life easier and the world a better place to live in?

If all the money that has been spent on needless warfare since Gilbert published the first systematic study of electricity and Harvey laid the foundation of modern medicine and Boyle pointed the way out of the wilderness of alchemy to the systematic paths of the new chemistry had been devoted to the training of skilled observers of natural phenomena, to an intensive study of the causes, prevention and cure of disease, to the possibilities of chemistry in the development of new products for the use of man and better uses for the old, to the enhancement of the world's supply of food and clothing through scientific methods of culture and breeding, in developing those physical facts and processes, our present knowledge of which is comparable with that which the ancient derived of electricity from his stick of amber, and which may be capable of development into greater things than electricity has, how much farther would we have been toward making man the master of his condition?

There are a few institutions in the world, mostly endowed by farsighted men of large means, which are devoted to this kind of research. There are institutions, educational and otherwise, where devoted men delve into the secrets of nature actuated by an absorbing spirit of investigation. There are struggling possessors of ideas who are spending what they can eke out in time and money from the strife for existence in trying to make them realities. Specialized research for the betterment of their product, or methods, is carried on by many of the large industries. But these are sporadic, individualistic and not expressive of any convinced purpose on the part of mankind generally to quit quarreling over the nonessentials and find out what it can do for itself with the undiscovered possibilities of the means and materials at its command.

We are here upon this little island in the universe, and it would seem that the best use that we can make of the powers and faculties with which we have been endowed, and the facilities which we have developed would be to investigate the possibilities of our surroundings, the materials and forces at our command, so as to lighten the general burden, mitigate human suffering, and make life easier and better for everybody.

F. R. Low

Adjusting Direct-Current Generators For Parallel Operation

By EUSTIS H. THOMPSON

WHEN a new generator is added to a plant, it is customary to make adjustments on this machine for producing satisfactory parallel operation, so as not to disturb the original adjustment of of the plant; conditions sometimes occur that require adjustments to be made on the original machinery. There are three adjustments necessary on a compound generator: (1) The compounding, or change of voltage from no load to full load; (2) the resistance of the series-field winding together with the lead connecting it with the busbar; and (3) resistance of the equalizer. When a generator is purchased, the "compounding" is usually adjusted in the factory to that of the plant itself. Much trouble and loss of time can be avoided in many cases by figuring out the resistance of the path of the current through the series field and the lead to the busbar that is required, and advising the manufacturer on this point, so that a resistance will be provided, if necessary, for adjusting this portion of the circuit. Equalizers are usually provided with an area equal to that of the conductor from a machine terminal to a busbar.

It is frequently necessary to operate direct-current generators driven by different types of prime movers in parallel, such as engine-driven and turbine-driven machines in multiple. On the other hand, engine- or turbine-driven units may be operated in parallel with motor-driven generators. The author in this article deals with these various combinations and explains the adjustments necessary to obtain satisfactory parallel operation.

Before specifying these conditions for a new machine, it is best to make sure that the plant, as it stands, is in good condition and that the compounding of the machines is satisfactory, so that it will not be necessary to make repairs or adjustments to the units at a later date, which will disturb the conditions of multiple operation. The governors and valve gears should be in standard condition both in regard to no-load speed and also governor regulation, or in other words, the drop in speed from no-load to full-load conditions.

The compound or voltage variation of the plant from no load to full load is usually obtained without difficulty by taking readings from the busbars, with all the generators operating if the load is available for this, or by averaging up the compound of the various units in case there is variation. Very often the station must be adjusted to a certain compound in order to give the proper voltage variation at the different distributing points.

Series-field and busbar-lead resistance of the new machine should give the same drop in potential at full load as is obtained on other machines in the station. Fig. 1 shows the connections of two compound-wound machines in multiple. If the voltage is read on a low-reading voltmeter, at the points E_1 and E_2, with full load on the machines, the resistance for a similar connection on the new generator can be figured by dividing its full-load current into this reading. If the manufacturer is advised of this resistance and the types of machinery already installed, together with the size and length of cable from the machine terminal to the switchboard, he can make provision accordingly.

The equalizer is usually connected from the machines to an equalizing bus on the switchboard. When the switchboard is 100 ft. or more away, there is sometimes a surging of current due to the resistance of such an equalizer. This is noticeable more especially with modern generators containing interpoles or compensating winding. In such a case the trouble must be overcome by increasing the cross-sectional area of, or shortening the equalizer. An equalizer bus can be run from one machine to the other, using equalizing switches mounted on floor pedestals, or on the machines themselves, so that the run to the switchboard is eliminated.

The usual method of placing a generator in service is first to try the machine, as furnished by the manufacturer, to see if multiple operation is satisfactory. When the generators are of the same type with similar prime movers, and especially where the machinery is all produced by one manufacturer, little trouble can usually be expected and close adjustments of the machine may be unnecessary. Where different conditions are encountered, such as an old-type engine-driven generator, which does not contain interpoles, together with a modern turbo-generator, difficulty may arise.

Engine governors may be more uniform in regulation, so that the speed tends to drop in a direct ratio to the load. Some turbine governors may have a tendency to drop very little in speed as light loads come on, while the speed would drop more rapidly with heavy loads such as full load or overloads. The foregoing is not always the case, but represents what may possibly happen. This would produce a tendency for the turbo-generator to take more load at first, so that the engine-driven unit would carry less than its portion of the load, and then when heavier loads occurred, the engine would tend to pull more than its share. This action, of course, will be neutralized to some extent by the equalizer.

The series-field winding on older-type generators without interpoles contains a certain number of ampere-turns to strengthen the shunt field as the load comes on, in order to make up for the weakening effect that the armature reaction or magnetism has in opposing the shunt field. In addition to these turns for strengthening the field, there are also a number of ampere-turns for building up the voltage as the load increases.

In a modern machine the interpole winding contains ampere-turns that tend to neutralize or "buck" the armature magnetism, so that there may not be as much tendency for the armature reaction to weaken the shunt

fields as in the older machine. The series field of a modern machine does not require as many ampere-turns as compared to an older machine, because it is not required to strengthen the shunt fields to the same extent. An older type of machine has a much more positive equalizing effect, due to its larger series-field winding, than the modern machine with its comparatively weaker series field. There is, therefore, more tendency of an interpole machine to be less positive in equalizing or dividing the load properly.

Modern high-speed turbo-generators are sometimes encountered which contain more iron in the magnetic

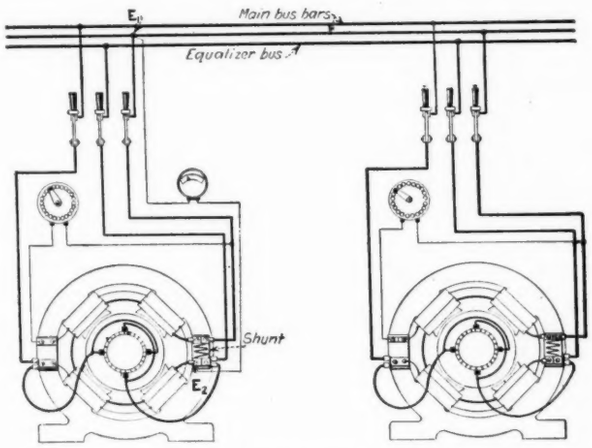


FIG. 1. TWO COMPOUND-WOUND GENERATORS CONNECTED IN PARALLEL

circuit and less copper in the windings, comparatively, than the older machines. The voltage curve of such generators is usually much higher at light loads, such as a quarter load, than the older machines, and the fall of voltage from this high point to the full-load value is consequently much more rapid than the earlier generators. Fig. 2 illustrates how such curves may vary. This has a further result of causing the turbo-generator to carry more than its share at light loads and then give up in favor of the engine generator as the load approaches normal. There is also more tendency, in such a modern machine, for the load to vary or surge, so that sometimes it may carry exactly its share, sometimes more and sometimes less.

An interpole machine is especially sensitive in regard to brush shift, as shifting the brushes against rotation tends to increase the compound, while shifting with rotation tends to decrease the compound. The position of the brushes, however, is determined almost invariably by the position that will give best commutation. Manufacturers are often very particular in locating and marking the correct position of the brushes, and it is inadvisable to change this position for the purpose of adjusting the compound. In some cases the brushes may be shifted slightly for adjusting voltage variation without harm, but it is difficult to tell whether bad effects will follow or not, as bad commutation may not fully appear until some later time. These brushes are usually set on the electrical neutral point, or else given a very slight shift with rotation. Brush position is the most sensitive adjustment of high-speed generators, and special pains must be taken to see that the adjustments of the interpole winding and brush position are in accordance with the manufacturers' connections.

When the voltage curves of generators vary to a considerable degree, as indicated in Fig. 2, it is not always practical to endeavor to produce perfect multiple operation. If the generators can be operated together satisfactorily at no load, and when full load is applied they divide the load within 5 per cent of their various capacities, it will ordinarily be satisfactory, even if the intermediate loads do not divide as well. It is, of course, desirable to adjust the generators so as to divide at full load within 1 or 2 per cent of their respective capacities, if possible.

If trouble is experienced in multiple operation, the series-field resistance can be checked to see that the voltage drop, in this part of the circuit, on the new generator alone is the same as on the rest of the machines. If this resistance is lower, the new generator will tend to take more load, and have the opposite effect if it is larger. If the current is seen to surge or vary in an unstable manner, it indicates a high resistance of the equalizer circuit or a loose connection in this circuit. It is usually most satisfactory to adjust this resistance as already described and adjust the ability of the machine to take more load or less load by increasing or decreasing the strength of the series field.

Engines and Turbines

Trouble is rarely experienced when engines and turbines drive generators in multiple, when the prime movers are in good adjustment. If the flywheel of an engine is too light, the pulsations of the crank will be apparent on the generator by surges of load at every stroke. Whether such surges are large enough to cause inconvenience can be decided best by the man on the

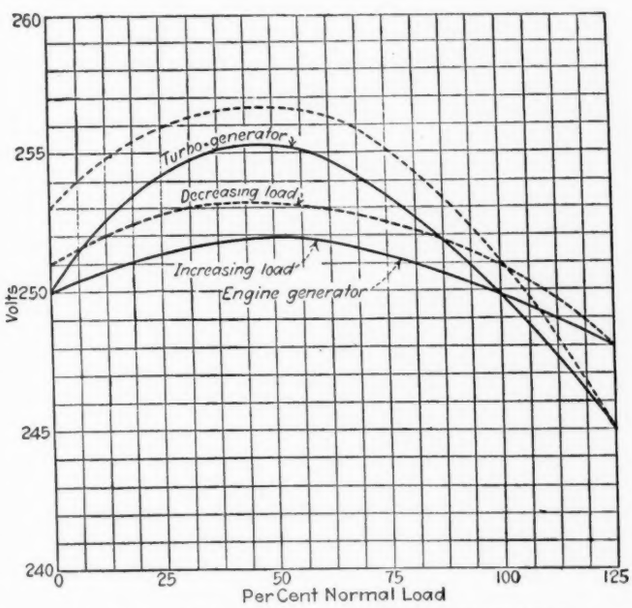


FIG. 2. LOAD-VOLTAGE CURVES OF COMPOUND-WOUND GENERATORS

job. Such a condition is rarely found with engine-driven units. If the engine regulation is excessively broad, on in other words if the drop in speed from no load to full load, instead of being 2 per cent or 3 per cent, should happen to be 5 per cent or 10 per cent, it is probable that inconvenience would be experienced, even if the voltage compound of the generator were adjusted correctly. The flywheel under the latter condition would slow down a greater amount when a heav-

load occurred than with close regulation. It would, therefore, give up more energy than under the former conditions, so that the engine generator would tend to take more than its share of a sudden surge at first, and then later divide equally when it had dropped in speed sufficiently to give the proper valve opening. On the other hand, if a turbine governor had excessive regulation, even though the generator were properly compounded, it would have a similar effect, in taking the load at first.

Turbines and engines, when in proper adjustment, usually divide both the surges and steady loads according to the capacities of the generators in a regular and even manner. Occasionally, it occurs that the difference in inertia causes one or the other of the machines to take the greater part of a sudden load at first or to give up more quickly on decreasing load.

Gas engines, in proper adjustment, usually give first-class multiple operation with turbines. A missed explosion, however, may cause the generator to lose an appreciable amount of load momentarily.

Induction-Motor Drive

An induction motor drops in speed as load comes on in the same way that a turbine or engine does. Ordinarily, its speed regulation is practically the same in regard to both amount and uniformity. In other words, it will slow down practically the same amount for the same percentage of load increase. An induction motor-generator set usually has less inertia than an engine or turbine set. When running in multiple with such prime movers, a sudden overload will be taken up by the latter until the inertia is overcome, so that they slow down in order to give sufficient valve opening. After the valve opening has adjusted itself, the two types of units will share the load in proper proportion. Such action is momentary and would not occur in normal load variations, and would ordinarily not be noticeable.

Synchronous-Motor Drive

Synchronous motors do not slow down as the load comes on, ordinarily. Their speed is fixed by the frequency of the system, since the rotating element turns at the same speed as the revolving flux caused by the alternating-current winding. When a synchronous motor is pulled "out of step" so that its speed of rotation is different from the revolving flux, excessive currents are set up, so that its switch would probably be tripped open by the overload attachment. The latter effect is caused by an excessive overload or a rapid change in the frequency of the system supplying it. A surge of voltage on this system may also cause it to trip out.

As the synchronous motor does not slow down when load comes on, it tends to take the greater part of a sudden heavy surge, when running in multiple with a turbine or engine-driven generator set, until the latter has slowed down to admit sufficient steam, which is only a very small interval of time. Prime movers of the latter type usually handle sudden excessive overloads by dropping below the proper speed while the valves are opening and then gradually rising and closing the valves until the proper speed value is reached. When handling normal changes in load, the governor is quick enough to produce the proper valve opening as soon as the machine has slowed down to the required speed, so that there is practically no rise after the lowest point is reached. On account of synchronous motors having different speed characteristics from other prime movers, difficulty is sometimes experienced in equalizing such sets with those driven by other types of machines. With careful equalizing adjustments, multiple operation should be satisfactory.

Induction motors and synchronous motors are both subject to being slowed down or speeded up on changes of frequency of the system from which they are supplied with power. When main units in a plant are slowed down by a short-circuit and then speed up on the opening of a feeder switch, there will be a corresponding change in the speed of the motors. If they are driving exciters in multiple with steam-driven units, surges of current may be expected, and the synchronous motor may be thrown out of step.

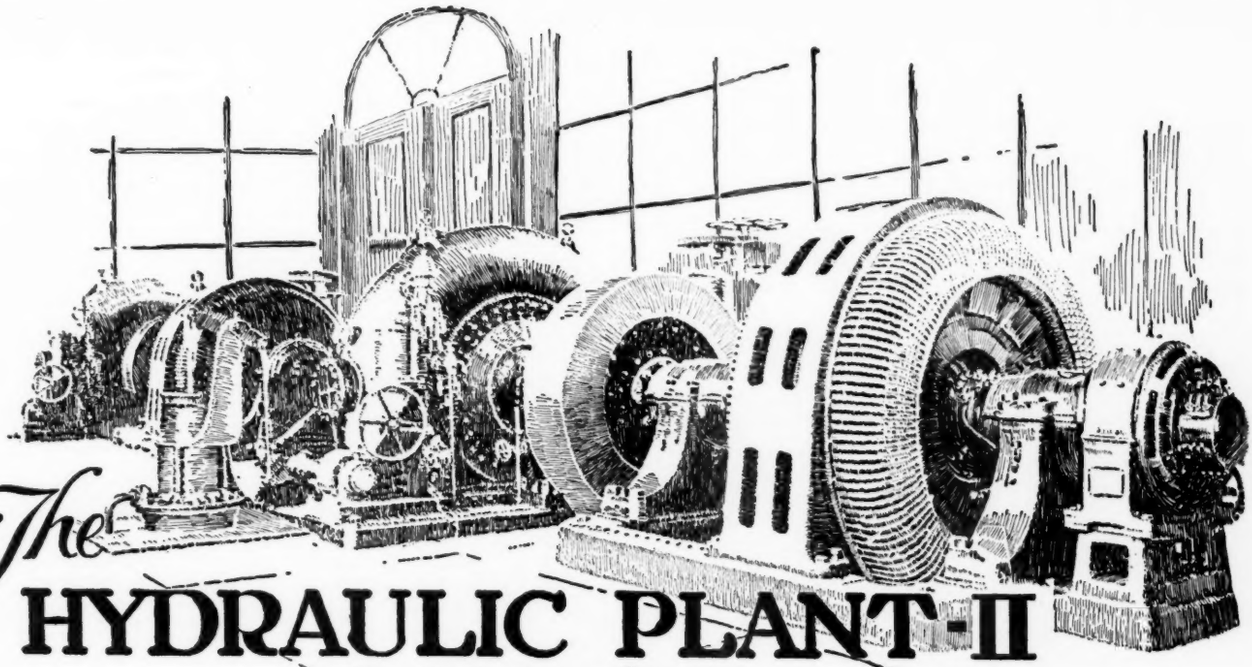
An English Welding Process

The desirability of joining pieces of metal together by other than mechanical means has brought the arts of welding, brazing, and soldering to a considerable degree of perfection. Where great mechanical strength is required, the third of these can be neglected, and the other two are under the disadvantage that it is often almost impossible to be sure that they are absolutely sound. Welding and brazing, nevertheless, occupy a very important place in the processes of construction and would be even more widely used if some of their drawbacks could be eliminated.

A few years ago a method of uniting iron and steel that partakes of the nature of both welding and brazing was invented by A. D. Hyde of the Vactite Wire Co., Acton, England, and the Hyde Welding Co., Wolverhampton, England. This method, which is now in regular commercial use and is known as the Hyde welding process, consists essentially of uniting the surfaces by means of molten copper, but differs from brazing in the fact that the copper impregnates the masses of metal to be joined and unites them in such a way that they cannot again be separated by heat. The Hyde process is usually carried out simply by placing together the pieces to be joined with a small piece of copper wire or strip adjacent to but not between the joint, and then raising the whole to the melting point of copper, while surrounded by an atmosphere of hydrogen.

There appears to be no difficulty in securing a perfect union by means of the copper, even though the surfaces to be joined together are covered with scale or rust. Neither does any crevice seem too small for the copper to enter. It is stated that when a steel plug was driven tightly into a hole and a little copper melted around the joint for only a few seconds in an atmosphere of hydrogen the copper found its way between the surfaces that were apparently in absolute contact.

Saying coal is "destroyed" to convert its heat energy into a mechanical or an electrical form of energy is not very far from the truth of the operation, when it is considered that under the best conditions less than 20 per cent of the energy in the coal fired under a boiler appears in the form of electrical energy at the generator terminals, and in many cases this is as low as or even less than five per cent.



The HYDRAULIC PLANT—II

By N. L. Devendorf*

Types of turbine setting, forms of draft tube, effect of air leakage, vertical vs. horizontal turbines, thrust bearings, maintenance and repairs.

THE setting of the reaction turbine and the manner in which the water is led to it depend on its size, on the available head and other considerations which are the subject of careful study on the part of the designing engineer and must be determined in each case according to local conditions.

For low heads, up to 40 or 50 ft., the open wheelpit, Fig. 1, offers certain advantages and is widely used. Some of these advantages are a full vertical head directly over the turbine, which permits close and constant regulation without the problem of the inertia of a great mass of water in a closed conduit, large, free water passages in which the losses are reduced to a minimum, and ready access to the turbines for inspection and repairs, by simply closing the headgates and draining out the pit by a small opening of the turbine gates. The modern wheelpit is generally of reinforced-concrete construction and provided with vertical lift or tainter gates, motor-operated. Occasionally, stoplogs are used instead of gates, but this is not the best practice. Some of the best-equipped plants are provided with both headgates and stoplogs, the latter for use especially in case of work on the gates.

Riveted Steel Penstock and Wheel Case

For heads of over 50 ft. the riveted steel-plate penstock and wheel case, Fig. 2, are largely used, but the more recent practice, while retaining the riveted steel penstock, is to use the volute or spiral case, as the highest efficiencies cannot be obtained with the old-style cylindrical construction. The volute case is ordinarily made of cast iron, but in the higher heads for which the reaction turbine is adapted, it is sometimes made of cast steel. In the low-head plants the wheel case, with penstock and draft tube, are of concrete, being molded in the foundation of the building. The penstock and wheel case must be designed to withstand not only the hydrostatic pressure due to the head, but also those strains and stresses due to changes in the velocity of the water column, of which mention has been made in connection with the impulse turbine. Severe shocks are possible even with a moderate head.

If the penstock is long, even though the head is not great, provision must be made for relief from the effect of these pressure surges, and this is best done by the installation of an open surge tank as close to the plant as possible or, if this is not feasible, by the installation of some sort of relief valve. The riveted steel penstock is designed only for pressure from withing. When emptying a penstock, care must be exercised to see that the air vent to it is ample, otherwise it may collapse from the formation of a vacuum in it when the water is drained out. This has occurred twice in the writer's experience, on heads of between 50 and 100 feet.

The Draft Tube

When the water, having delivered as much of its energy as possible to the turbine shaft, leaves the lower lip of the turbine vanes, it passes through the discharge ring of the turbine and through the draft tube to the tailrace. The design of this last member of the setting of the reaction turbine is important, especially with low heads, and should be made by the maker of the turbine. In most of the older plants the draft tube is a cylinder of riveted steel plate, hung from the discharge ring of the turbine, Fig. 3, and extending downward into the tailrace, its outlet being submerged a foot or so in the tailwater. If the turbines are of the horizontal type, the discharge from the wheels passes first into the "draft chest," where it turns downward into the draft tube.

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In some of the newer installations the draft tube is turned from a vertical to a horizontal direction in a gradual curve and flared out from the discharge ring to the tailrace to reduce the velocity of the water as much as possible before it is discharged, Fig. 4. The tailrace must be large enough to carry away the water without backing up to any extent, but the outlet of the draft tube must always be submerged. For this reason the draft tube, when turned from a vertical to a horizontal discharge, is sometimes flattened out to an oval shape in order to reduce the depth of water necessary to cover it.

Draft-Tube Outlet Should be Under Water

When the tube is filled with water, and there are no air leaks into it, the falling water creates a vacuum, giving the effect of adding head above the turbine, so long as the vertical height of the tube is well within the theoretical limit of vacuum—about 34 ft. depending upon the barometer reading which is affected by altitude and by atmospheric conditions. If there is an air leak into the draft tube, either from the surface of the headwater, due to too little depth of water over the gates permitting the formation of air vortexes from any opening accidental or otherwise in that portion of the tube above water, or from too little depth of water over the outlet permitting air bubbles to enter, the vacuum will be broken, and the effect of whatever head is carried on the draft tube—that is, the head equivalent to the vertical distance from the discharge ring to the surface of the tailwater—will be lost. Consequently, it is necessary to see that the outlet of the draft tube is under water and that there is enough water above the turbine so it will not "take air."

This is of vital importance with low heads, where perhaps a third of the head is carried on the draft

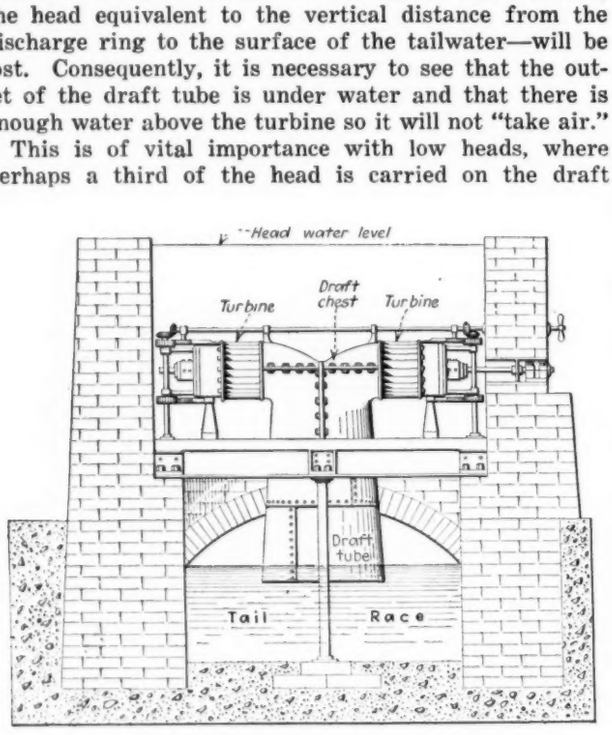


FIG. 1. OPEN WHEELPIT, LOW-HEAD CYLINDER-GATE TURBINE

tube. Once the vacuum is broken, by low headwater, low tailwater or other cause, the turbine will not give satisfactory service until after conditions are again normal.

It is rarely the case in a properly designed plant that there is any trouble on the tailwater end, but if there is, the draft tube should be lengthened a little on advice of the makers of the turbine. Aside from air leaks that should be guarded against, the usual cause is drawing the pond level so low in some operating emergency that air vortexes are formed. This condition may be recognized by swings and surges in the load, by the sound of air suction in the wheelpit and by the inability of the unit to carry more than a small part of its rated kilowatt load, though it may take on a heavy load of wattless current.

In one case in a plant with a 12-ft. head, the danger of air vortexes is met by exhausting the air from the

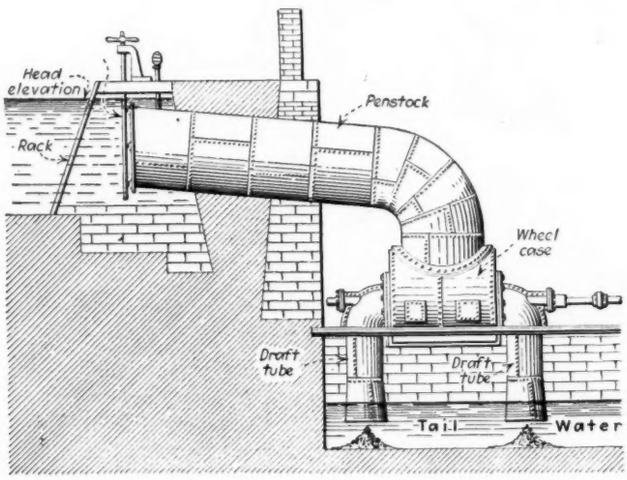


FIG. 2. RIVETED STEEL PENSTOCK AND WHEEL CASE

wheelpit so that the water rises in it several feet above the level of the pond. This is accomplished by the use of a curtain wall that is submerged below the low limit of pond level, on the upstream side of the pit, by airtight hatchways and manholes, by a well-packed gland around the turbine shaft, and then by means of a water-operated ejector a vacuum is created in the space above the water. Of course no head is gained, as the increased elevation is offset by an equal loss in the draft tube, but the danger of air vortexes is minimized.

A recent development of the draft tube is the "Hydraucone" regainer, Fig. 5. This consists of a bell-shaped draft tube, the curve of the sides of which conform to the natural shape of the hydraucone or mass of water as it leaves a straight tube and spreads out on a flat surface. This type of draft tube does away with swirls and eddies in the discharge pit and permits a free, unopposed passage of the water. It is an improvement over either the straight or curved draft tube, in that the change in the direction of flow is made with the least possible loss due either to the resistance of the curve of the tube or to the eddies and cross-currents developed at the discharge of the straight vertical tube.

Vertical vs. Horizontal Turbines

Vertical-shaft turbines were commonly used at the beginning of hydro-electric development, being connected to the generator by bevel gear and belt or, later, by rope drive. There are some of these plants still in existence, but many have been superseded by more modern units on account of the losses between the turbine and generator. Often the gears, with the numerous bearings necessary with this arrangement, will consume 40 to 50 per cent of the turbine's energy, and

where these have been replaced it has been found that the output of the plant has nearly doubled on the same head and stream flow. The maintenance in this type of plant is high, as worn step-bearings or "niggerheads," fallen crown wheels (the large bevel gear on the vertical shaft) worn, loose and broken wood teeth on this gear

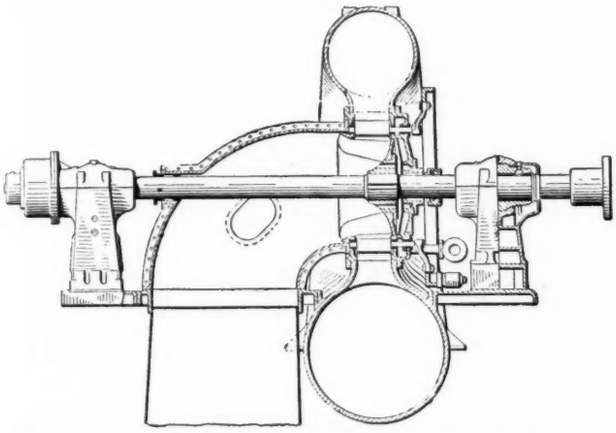


FIG. 3. DRAFT TUBE HUNG FROM DISCHARGE RING

and other faults develop when this construction is subjected to the strain of continuous service.

The next step was the horizontal turbine. These were generally built in pairs or, in the larger low-head plants, in groups of pairs. Each pair consists of a right-hand and a left-hand runner discharging into a central draft chest and a common draft tube, Fig. 6. This arrangement balances the thrust of the runners, so there is no end play to the mainshaft. These units are direct-belted in some of the smaller sizes, the larger sets being direct-connected to their generators.

In both of these types of turbine the submerged bearings are of lignum vitæ, and depend upon water lubrication, though in some large horizontal units heavy grease is forced into the bearings daily, and perhaps some of it is retained. These submerged bearings should be inspected and taken up for wear at regular intervals, dependent upon the amount of silt in the water, but in any event at least once a year.

Maintenance an Important Matter

Maintenance of these older types of turbine installation is an important item and should be handled by a competent millwright. Especially, only experienced men should be intrusted with such work as retoothing crown wheels, aligning shafts and the like. Much time, trouble and revenue can be saved by systematic inspection and the immediate following up of any symptoms of distress that may be observed. Plenty of spare parts and material should be kept on hand. If the shafting and gears are out of alignment, the friction losses are increased greatly and with it the wear and tear.

With the development of the modern overhung thrust bearing, the vertical-shaft turbine has returned to favor, and in the last few years the improvements in the vertical unit have been almost revolutionary, so that it seems improbable that many more plants will be installed with horizontal reaction turbines as the prime movers. These plants are becoming so familiar to operating men that an extended description seems unnecessary. The turbine does not differ greatly in its general appearance from the older types except in the recent development of the high-speed "propeller" type wheels, but instead of the weight being carried on a lignum vitæ step bearing under the end of the shaft, it is supported from above with the rotor of the generator and generally the exciter armature, on a single bearing mounted on the top of the generator frame.

Type of Thrust Bearings

There are several types of these thrust bearings in use, but those giving the most satisfactory service at the present time depend on a film of oil drawn in between two rings or circular plates, one of which is keyed to the shaft and revolves with it, the other being stationary. The contact surfaces are submerged in an oil bath and are so arranged that the oil wedges between them and is drawn out into a thin film which carries the weight of the rotating parts and is continuous so long as the machine is in motion. In one type the stationary element is divided into four segments, so spaced that there is a free circulation of oil. Each of these segments or shoes has a single pivot support slightly off the center, in the direction of rotation. This allows a small opening at the opposite end into which the oil wedges as the shaft rotates. Another type has two rings with radial oil grooves cut with slanting sides to produce the wedging effect. In this type the stationary ring is supported on springs which take care of any slight inaccuracy in alignment that may develop. The stationary bearing surface in both types is babbitted; the rotating ring is of polished steel. Although the thrust bearing is properly a part of the generator, it is described here, as it makes possible the use of the large vertical shaft runner that has been found the

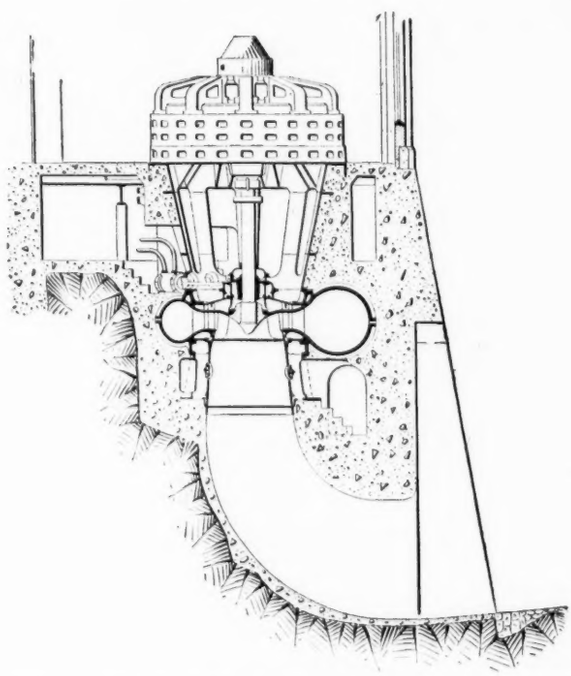


FIG. 4. DRAFT TUBE TURNED FROM VERTICAL TO HORIZONTAL DIRECTION

most satisfactory and efficient prime mover yet developed for low- or medium-head hydro-electric units.

The guide vanes of the turbine in most modern makes are pivoted and used as gates to control the flow of water into the runner. These gates are handled from

the "operating ring" located on the turbine casing around the shaft. A short lever is attached to the pivot on each gate and to the operating ring, which turns the gate when the ring is turned by the governor or hand control. These levers or links are so designed that they are the weakest part of the mechanism, and if a stick or other obstruction is caught in one of the gates, its link should snap off, leaving the other gates free to operate.

Inspecting Gate Mechanism

In the older horizontal and in all open-wheelpit types of setting the gate mechanism is under water and should be inspected and overhauled every time the water is drawn off. This submerged gate mechanism may sometimes be so clogged that it will refuse to operate. It is important that the headgates be kept in shape to be closed on short notice, for while the turbine and generator are designed to stand a considerable increase in speed above normal, it is not good for the unit, and especially for the exciter armature to operate for any length of time at runaway speed, which may be 200 per cent of normal. It will be found that stoplogs are rather difficult to handle in stopping a runaway wheel, and if they must be used, means must be provided for forcing them down with powerful screw or hydraulic jacks against the current.

The hydro-electric plant should be provided with material and equipment for ordinary repairs, such as jacks and blocking, chain falls and all necessary heavy tools. These should be kept in good shape and where they will be quickly accessible when needed. A portable forge, a drill press, lathe, planer and emery wheel are good investments if the plant is situated at a considerable distance from a machine shop.

One of the most useful devices that can be provided, and which has almost revolutionized certain kinds of

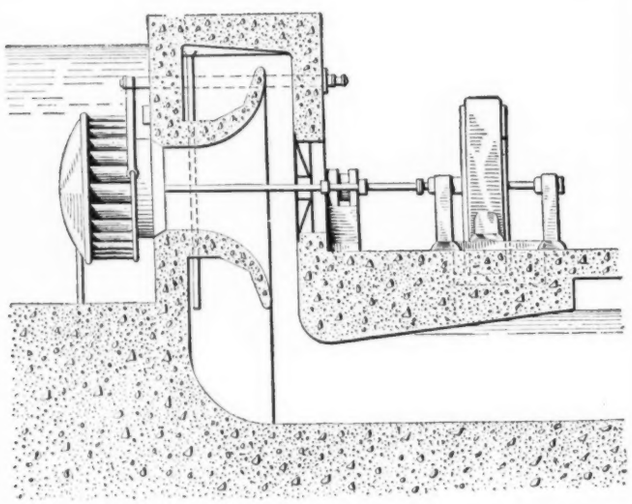


FIG. 5. TURBINE FITTED WITH HYDRAUCONE REGAINER

repair work in the last few years, is an oxyacetylene welding and burning outfit. Many jobs can be done in a short time with this little blue flame that would have taken hours, perhaps days, by the older methods. Teeth have been welded into broken pinions, heavy crown wheels that have been cracked have been made as good as new, and in removing old iron it can be burned into small pieces easily handled in a short time. A skilled welder is necessary to do a good job, especially on the larger pieces, and careful preheating to avoid cracking and warping the castings elsewhere. The oxyacetylene

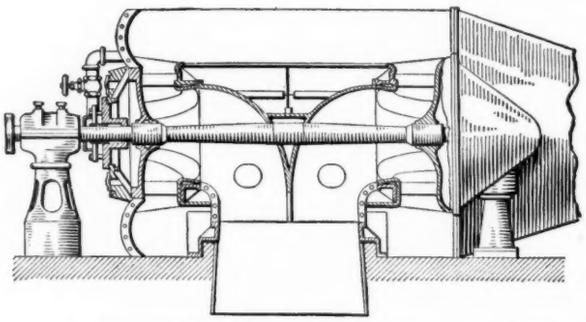


FIG. 6. TURBINES DISCHARGING INTO A COMMON DRAFT TUBE

torch is a great money and labor saver to the plant that is so unfortunate as to have a serious breakdown in the wheelpit.

Abrasiveness and Hardness of Carbon Brushes

Abrasiveness is that characteristic of brush material which causes surface wear of commutators and slip rings. No method has ever been devised for reliable determination of this characteristic, yet it has a most important bearing on brush operation. The manufacturer's description of specific grades or the operator's experience must usually be depended upon for information on this point. On commutating machines with undercut mica, little or no abrasiveness is required, but where the mica is left flush with the copper a mild abrasive action is, as a rule, desirable. Brushes with pronounced abrasive action should be avoided, as they result in unnecessary wear of revolving parts and frequently cause a deposit of copper dust over the windings of the machine which may lead to serious consequences. Where there appears to be a need for a pronounced abrasive characteristic in the brush, undercutting of the mica will in nearly every case be found a better solution of the problem. Furthermore, by using a type of brush having little or no abrasiveness, and undercutting the mica, the commutator will not be subjected to the wear peculiar to the abrasive brush.

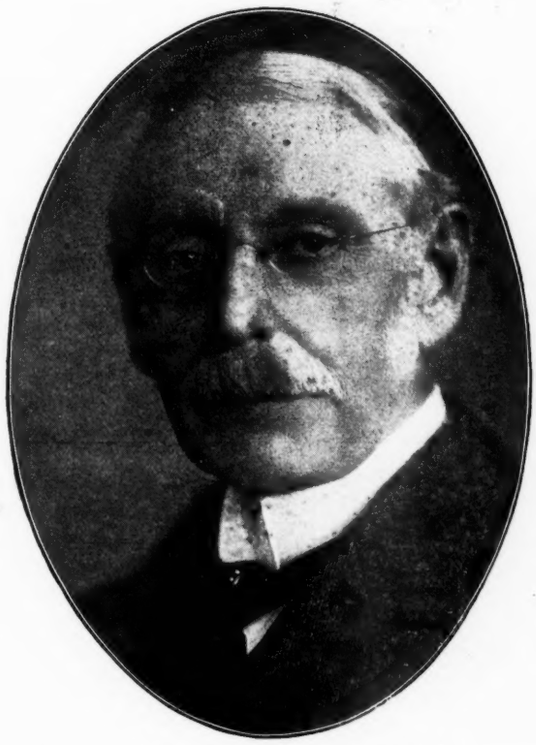
A great deal of confusion has existed in the past in regard to hardness and abrasiveness. The terms are altogether distinct and possess an entirely different relation to operation. The hardest brush may be non-abrasive while some grades of soft brushes possess a decidedly abrasive characteristic. Hardness is usually measured by an instrument known as the scleroscope and the readings will range from a few points for the soft graphite, and metal-graphite brushes to 60 and higher for very hard carbon brushes. Where quiet operation is an essential feature the softer grades of brushes, if of low coefficient of friction, may be found quieter than harder grades. Where brush life is the most important consideration, harder grades adapted in other characteristics to the operating conditions may give longer life than softer grades. In general, however, it may be stated that the hardness of the brush is to be given relatively little consideration in brush selection.

Sir Charles Parsons

The Life and Work of the Man Who Is Chiefly Responsible for the Successful Development of the Steam Turbine — Early Types of Turbines — Progress up to the Present, with a Glimpse of the Future

BY EDGAR C. SMITH
Engineer Commander, R. N., H. M. Dockyard, Devonport, England

UNLIKE the majority of great inventors, Sir Charles Parsons began his career with many advantages. A glimpse of his early surroundings can be obtained from the fascinating "Reminiscences" of the well-known astronomer, Sir Robert Ball. Some fifty-six years ago, in the autumn of 1865, Ball, then young and unknown, arrived at the small Irish town of Birr, or Parsonstown. He had been drawn thither, first by the offer of the post of tutor to the three younger sons of the Earl of Rosse, and second by the prospect of being able to use the great six-foot reflecting telescope at Birr Castle. The three boys were the Hon. Randal Parsons, the Hon. Richard Parsons and the Hon. Charles Algernon Parsons, and their respective ages were seventeen, fourteen, and eleven. Possessing great public spirit and a benevolent character, the Earl had for years spent much time and money in scientific pursuits. In 1845, after an immense amount of hard work, he had completed the great six-foot reflector which was long one of the wonders of the world.



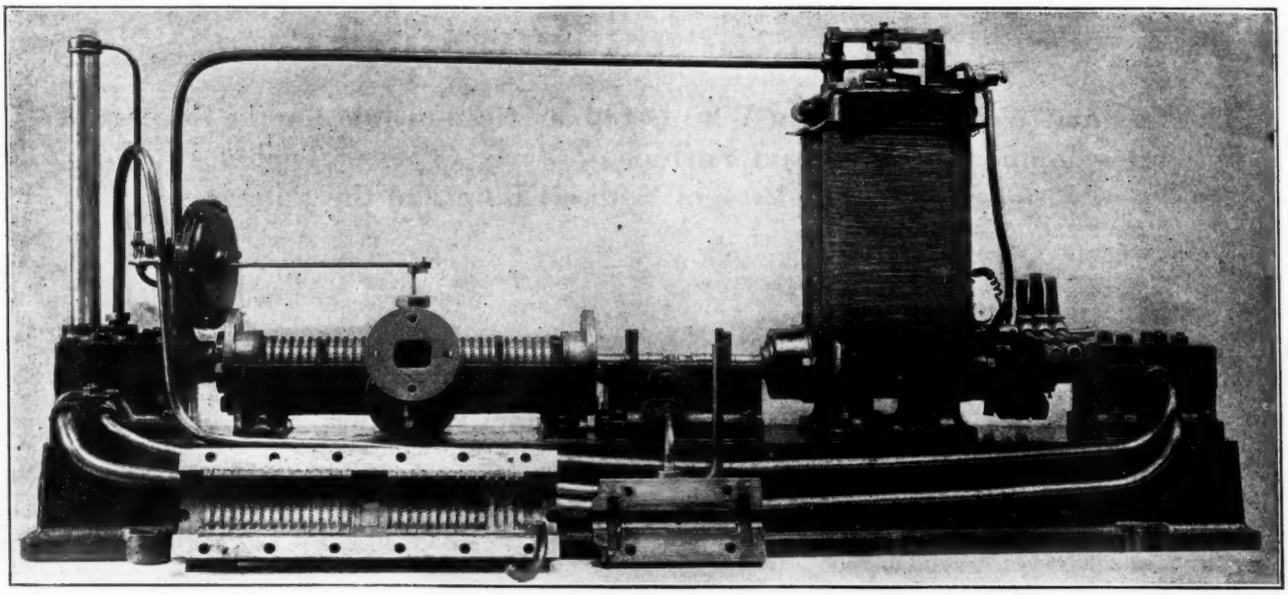
SIR CHARLES PARSONS

Life at Birr must have been an education in itself. Besides the moated castle and the park there was the gigantic telescope, the foundry and workshops wherein it was made, and books and tools to satisfy the demands of any boy. Then too, few men have possessed the art of exposition in a higher degree than Ball, who with wide attainments combined a genial temperament, a sparkling wit, enthusiasm and industry. After the duties of the day were over, a small workshop just off the library was, says he, "The constant resort of my younger pupil, the Hon. Charles Parsons. In this little den he was always making all sorts of machines. With the assistance of his brother, the future inventor of the steam turbine also made a steam engine, and I well remember the delight they took in grinding the reflector of a telescope in a machine that was driven by the home-made engine."

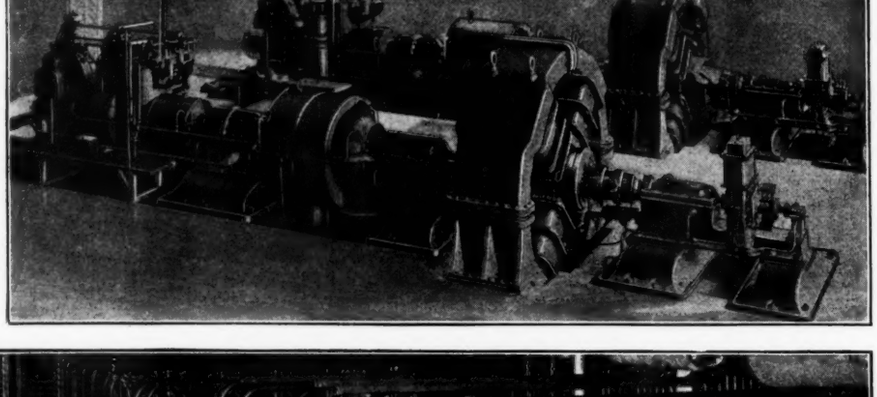
The education thus begun at Parsonstown under such favorable circumstances was continued at home for some years, when Richard was sent to Trinity College, Dublin, and Charles became an undergraduate of that famous home of mathematicians, St. Johns College, Cambridge. Graduating in engineering with honors in 1873, the Hon. Richard Parsons was connected for some years with a firm of engineers in Leeds and carried out important engineering work at home and abroad. His younger brother was graduated in 1876 and then spent four years at the famous Elswick works of Lord Armstrong.

In 1883 Sir Charles became a junior partner in the firm of Messrs. Clarke, Chapman, Parsons & Co., at Gateshead. It was there that he entered upon his life's work of bringing the steam turbine and the high-speed dynamo to a successful issue. The success of the turbine is due to the knowledge, skill and imagination which Sir. Charles Parsons has brought to bear on one problem after another, and also to the exercise of an indomitable perseverance in the face of many and great difficulties and discouragements. As told in Richardsons "The Evolution of the Parsons Steam Turbine," the story has few rivals in the history of engineering.

The design of a rotary steam engine having no reciprocating parts has fascinated many an engineer and inventor. Watt devised several rotary engines. Murdock, Hornblower and other old engineers tried their hands at it. The indefatigable John Bourne, seventy years ago, gave particulars of many of these old rotary engines. About 1845 the ingenious Lord Dundonald fitted his rotary engine in a small frigate, "H.M.S. James," but with little success; and Sir Charles Parsons himself, before he became engrossed with the turbine, constructed engines in which the four opposed cylinders revolved with the crankshaft but at half the speed. Similarly, many minds have attacked the problem of a steam turbine. Between 1800 and 1880 the British Patent Office alone recorded some 130 patents referring to such an engine. Six more patents were taken out in 1881, another in 1882, four in 1883 and four more in 1884. That year may be considered as introducing the birth of the Par-

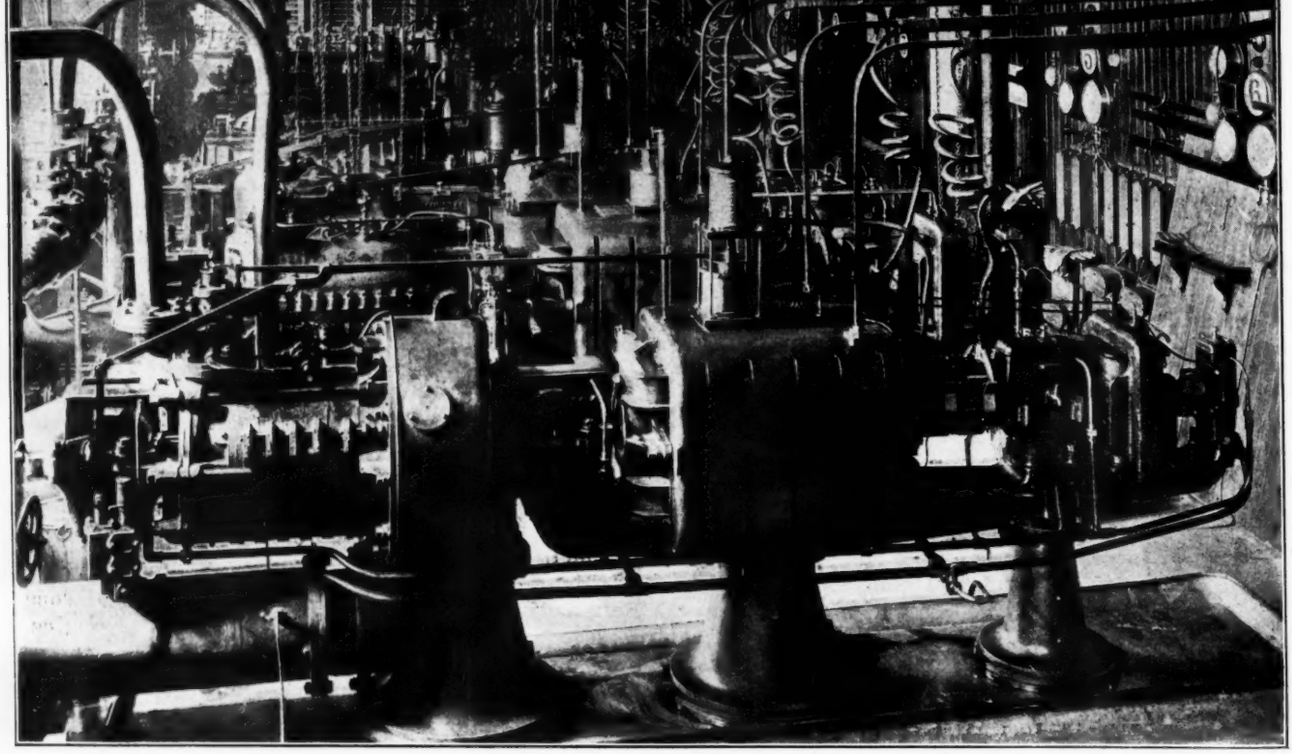


The first successful turbine, built by Sir Charles at Gateshead in 1884 and now in the Science Museum at Kensington. At 18,000 r.p.m. it gave about 6 hp. Steam entered at the center and exhausted at each end.



Right—An historical installation; the 1,000-kw. turbo-electric units built in 1900 at Heaton for Elberfeld in Germany. These machines were the largest in existence at that time, and their steam consumption of but 19 lb. per kw.-hr. strongly encouraged further development and use of turbines.

Below—Turbo-generators in the plant of the Newcastle and District Electric Lighting Co., Ltd., the first public-supply undertaking to use steam turbines. The machine in the foreground is of the radial-flow type, while the others are of the earlier, parallel-flow, double-ended type.



sons steam turbine and the high-speed dynamo. The first patent of 1884 was that of DeLaval, the eminent Swedish engineer who had already made a name with his cream separator, while the second and third stand in the name of Sir Charles Parsons. Both were dated April 23, No. 6,734 being for "Improvements in electric generators and in working them by fluid pressure" and No. 6,735 for "Improvements in rotary motors actuated by elastic fluid pressure, and applicable also as pumps."

The First Successful Turbine

The pioneer Parsons turbine, constructed at Gateshead in 1884, was a small, double-ended, parallel-flow machine which, running at the great speed of 18,000 r.p.m., drove an armature 2⅝ in. in diameter and gave about six electrical horsepower. A good view of the machine is shown on page 518. Steam entered the casing in the middle of its length, and then, passing among the blades, exhausted at the ends. The rotor consisted of a number of wheels on the edges of which were straight blades at an angle of 45 deg., cut out of the solid. In 1885 this machine was set to work to light a part of the Inventions Exhibition in London, but by most engineers who saw it, it was probably regarded more as a scientific curiosity than as the earliest representation of a type that was to revolutionize power plants both ashore and afloat. That same year another small set made its appearance at sea in the "Earl Percy," and in 1888 a Parson's turbo-generator for the first time lighted passengers during their voyages between Europe and America in the liner "City of Berlin." By 1889 some 300 machines up to 75 kw. had been constructed, and it was evident that the steam turbine had come to stay. The little historic engine of 1884 now occupies a place in the Science Museum at South Kensington beside the engines of Watt, the engines of Bell's "Comet," the "Puffing Billy" of Hedley, and the epoch-making "Rocket" of George Stephenson.

In 1889 the partnership of Sir Charles Parsons with Messrs. Clarke, Chapman, Parsons & Co. ended, and for the next five years he found himself cut off from the original patents, which remained under the control of the firm. Unable, therefore, to carry on with any form of parallel-flow machine, he and his colleagues turned their attention to the construction of radial-flow turbines, new works being erected for this purpose at Heaton, near Newcastle. Inward-flow and outward-flow machines were built, and with the latter a certain amount of success was achieved. The five years, 1889 to 1894, however, were mainly years of experimental investigation, and such points as leakage, lubrication, bearings, thrust blocks, dummy pistons, governing, blading and labyrinth packing were all the subject of extended inquiries. Among the experiments were some, even, with the æolipile[1] of the old Alexandrian philosopher, Hero, who lived in the first century of our era.

The recovery of his patents by Sir Charles Parsons in 1894 was, says Richardson, an event of national importance. The years 1884 to 1894 in some ways may be compared with the first ten years of Watt's partnership with Boulton, Watt in that time turning the bungling engine "Beelzebub," which he had brought to Birmingham from Scotland, into the powerful rotary engines such as made England the power house of the world. Sir Charles in his turn had attacked and solved a hundred problems and now, having come into his own again, was able immediately to apply himself to the development of his great invention. In 1887 the first compound turbine was made; 1892 saw the first condensing turbine. By 1892 machines were built up to 100 kw.; by 1902 up to 3,000 kw.; while today the largest turbines develop up to 60,000 kw. and the consumption of steam has been greatly lessened. In Great Britain no less than 80 per cent of electric generators are turbine-driven.

That the turbine could be used for driving steamboats was recognized quite early, though the question was not seriously considered until 1892. Two years after this, model boats two feet and six feet long were made and driven by very fast propellers. At the same time a new company, the Parsons Marine Steam Turbine Company, was formed at Wallsend-on-Tyne, and the building of the "Turbinia" began. This little vessel, which may be classed with Fulton's "Clermont," was 100 ft. long and of 44 tons displacement. A water-tube boiler with straight tubes of ⅝-in. diameter provided steam at about 200 lb. pressure to drive a single, radial-flow turbine and a single shaft. In 1895 this turbine was replaced by three turbines in series, giving about 2,000 hp. and driving three shafts; the speed was about 2,000 r.p.m., and on each shaft were three propellers. (Single propellers on each shaft were later found to be preferable for ordinary vessels.) Engined thus, the boat went through a great number of trials and in 1897 she made her official début. During Queen Victoria's Diamond Jubilee Review at Spithead in that year, the "Turbinia," at the request of the Commander-in-Chief, steamed up and down the lines at a speed of over 30 knots. Such a performance had never been seen before. The adoption of the turbine, both for warships and merchant vessels, followed rapidly, and by 1919 it was estimated that marine installations totaled something like 35,000,000 horsepower.

Development of the Turbine on Land

In any general historical review of the progress of the steam turbine emphasis is naturally laid on its extraordinary success at sea. Scarcely less remarkable, however, has been its development for driving electric generators, while it has also attained considerable popularity for pumping, blowing, and for driving rolling machines. Steam turbines in large numbers have been fitted for utilizing the exhaust steam from intermittently working reciprocating engines. The great central power station—one of the features of our industrial era—is now almost entirely equipped with turbines. In the year 1900 the largest turbo-generator had an output of about 1,000 kw., and the turbine of that time is well represented by that made at Heaton for Elberfeld in Germany (see page 518). Designed to meet the stringent conditions laid down by a commission of experts, the Elberfeld machine at full load had a consumption of about 19 lb. of steam per kilowatt-hour, a result up to that time not attained by any reciprocating engine. By 1904 machines were at work giving 4,000 to 5,000 kw. As the size has increased, so has the efficiency improved, higher pressures and higher superheating being employed. In 1912 the pressure had risen to 200 lb., while the temperature of the steam was under 600 deg. F. The steam pressure has now

[1]The æolipile is sometimes called the first steam engine. It was a hollow ball or cylinder turning on a hollow axle through which steam was admitted. The steam was discharged through bent nozzles with a pinwheel effect, causing the device to rotate.

risen to 450 lb. and the temperature to 750 deg. F. in some instances, although average practice is somewhat lower.

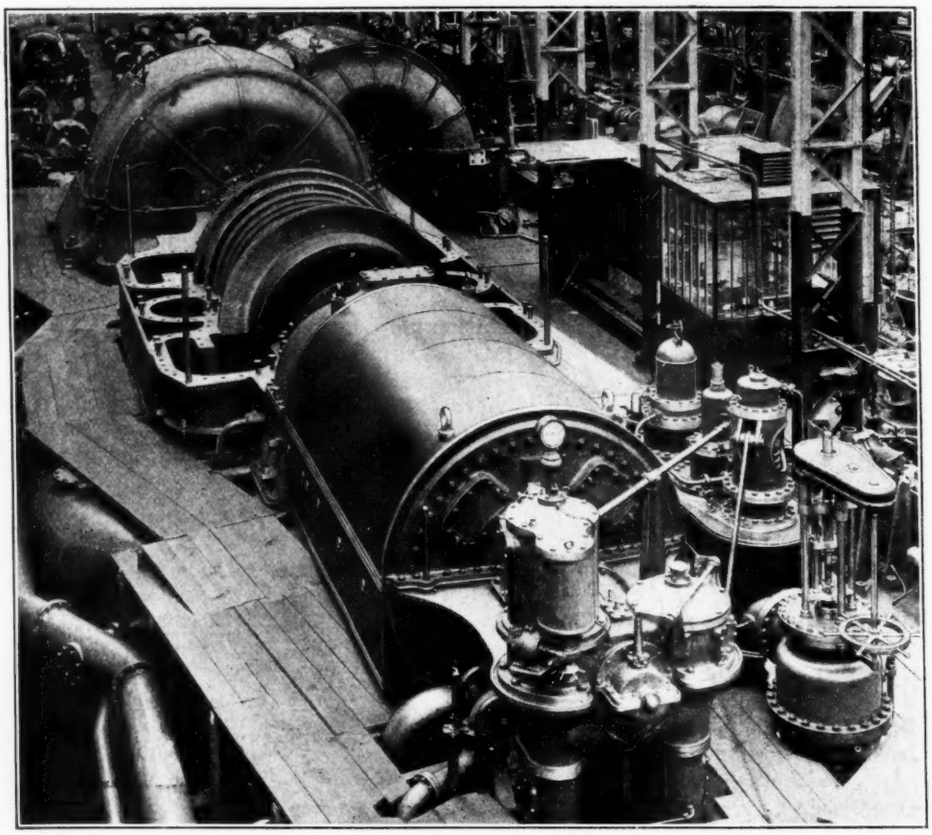
Among the very large units one of the first was the 25,000-kilowatt machine supplied to the Commonwealth Edison Co. of Chicago by the pioneer firm of Messrs. C. A. Parsons. This has been followed by American-built units of 45,000 and even 60,000 kw. built by the Westinghouse Electric and Manufacturing Company, the former being built in two units and the latter in three. One of the 60,000-kw. units is now in operation at the Colfax Station of the Duquesne Light Co. and has a guaranteed water rate of 10.53 lb. per kw.-hr. at 50,000 kw. and 29 in. of vacuum.

Born in 1854, just before the Crimean War sounded the knell of the grand old wooden line of battleship, Sir Charles Parsons has lived to see the greatest naval battle in history fought between huge armored steel ships driven at high speeds by the engine of his devising, which has created a revolution in naval affairs. In the history of that revolution, which is second only in importance to the change from paddle to screw, there is no more important name than his.

It is true, his work came at an opportune moment. In the 50's Isherwood and John Elder were only just beginning the study of the compound engine. Bessemer was attempting to solve the problem of the direct production of steel, and Armstrong, Krupp and Whitworth were fighting the first battle of modern artillery engineers. They knew little about thermodynamics, and electric machinery was scarcely in its infancy. In 1857, indeed, the idea of electric motive power was condemned by all the leading engineers, and even Faraday classed the magneto electric engine with mesmerism and homeopathy as among the "Ill weeds that cannot be extirpated yet can be cultivated to no result as wholesome food for the mind."

In the succeeding thirty years the whole atmosphere of power engineering changed. The labors of Siemens, Wild, Gramme and others led to the construction of efficient dynamos. Edison and Swan had invented the incandescent lamp, and the triple-expansion engine had made its appearance. At the Vienna Exhibition of 1873, out of 400 steam engines exhibited, the majority were of the Corliss type. Twelve years later the first Parsons machine was lighting the grill at the Invention Exhibition in London, while in 1891, at Frankfort, 109 hp. was transmitted electrically over a distance of 100 miles. The modern part of the story is one with which most of the readers of *Power* are familiar.

During the last twenty years many acknowledgments have been made of the brilliant services rendered to mankind by Sir Charles Parsons. He is a graduate of various universities, a Fellow of the Royal Society and a K.C.B. Last year the Franklin Institute awarded him the Franklin medal. His continued interest in power problems, not only of the present but also of the future, was shown by his presidential address to the British Association two years ago, when he returned to the consideration of the question of cutting a very deep hole in the crust of the earth. Though the boring of a shaft twelve miles deep may today appear chimerical, yet to us it is far nearer the realm of possibility than would have been the projects of steam propulsion and electric traction to the philosopher who devised the first steam turbine nearly two thousand years ago.



THE 25,000-KW. TURBINE SUPPLIED TO THE COMMONWEALTH EDISON CO.

[Considerable interest was developed a few years ago in the use of volcanic steam for power purposes in Italy. (See *Power*, Jan. 23, 1917.) This steam, however, is of comparatively low temperature (150 to 190 deg. F.). Robert F. Griggs, Director of the Katmai Expedition of the National Geographic Society, reports in the September number of the *National Geographic Magazine* that at the great volcano, Mount Katmai, Alaska, steam was found discharging from some of the vents at temperatures as high as 1,200 deg. F. In the hottest vents the steam is so dry as to show no signs of condensing for a long distance after leaving the vent. Wood shavings, when withdrawn into the air after being thrust into the steam, immediately ignited into a flame. Unlike the volcanic steam of Italy Mount Katmai's source is so far removed from civilization as to be of little use other than scientific interest.—Editor.]

Internal-Combustion Engines*

The Development of the Solid-Injection Oil Engine

By Dr. CHARLES E. LUCKE

AS A RESULT of a pretty general knowledge of the conditions surrounding the solid-injection semi-Diesel or surface-ignition engine, attention has been directed toward substitutes that would have some of the good qualities they had—simplicity, cheapness, foolproofness—but also the good properties of the Diesel—cold walls, ignition by compression and greater independence of fuel quality. Efforts to produce a cold-wall engine are directed along both lines. One is the explosive combustion engine; the other the non-explosive combustion engine.

Cold-wall explosive-combustion solid-injection engines are comparatively new, and the first one illustrated is the British Crossley, Fig. 1. It has a piston with a conical end and on the conical end a cylindrical projection *A*. The cylinder head is completely water-jacketed, in the side of which is the spray nozzle. As the piston approaches the head, the projection on the piston will pass the corner of the cylinder head, at which time the air in the annular space *C* is trapped. The projection *A* has a loose fit in the combustion-chamber opening, but not too loose, so that during the time it is passing into the head bore, there is a violent stream of hot compressed air down the sides of the combustion chamber and back along the center. Into this stream of air is injected a fine spray of oil, that is instantaneously ignited. The injection of the oil, its mixture with the air, its ignition and combustion, all occur almost instantaneously, the whole thing being controlled by the pump as to timing. Combustion is explosive in

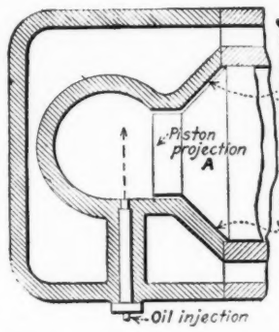


FIG. 1. CROSSLEY CYLINDER HEAD

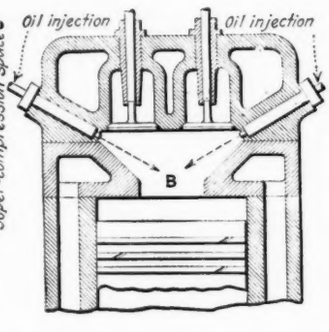


FIG. 2. PRICE CYLINDER HEAD

type, but in practice takes place both at constant volume and at constant pressure.

We have in this country an American representative of the same class of cold-wall explosive-combustion solid-injection engine in the Price construction, Fig. 2, which works differently; combustion is, normally, explosive in fact. Here a fine spray is injected into a conical combustion chamber on each side of a central cylindrical combustion chamber having a wide cylinder neck *B* up which a gentle air current rises during compression. This upward current and special shape of combustion chamber serve to mix the fine spray with the air during the end of the compression stroke. Compression is adjusted so that ignition temperature is reached just before the end, and as the air charge before compression is cooler at no load than at full load, the misfires that would happen, due to failure to reach ignition temperature at low loads, are prevented by an

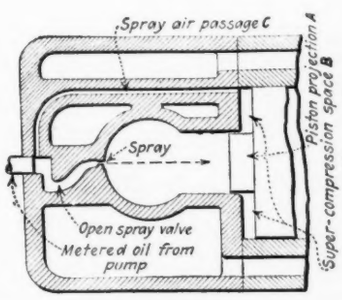


FIG. 3. HASSELWANDER AIR INJECTION DEVICE

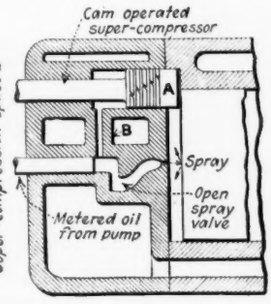


FIG. 4. KORTING-TRINKLER AIR INJECTION

air throttle having the effect of retaining enough hot burnt products to avoid the misfires. Should the air charge get too hot from any cause, the whole charge might be ignited everywhere at the same time before compression was complete, producing a detonating combustion with an explosive shock. Later injection would correct this if the charge were hot enough or compression high enough, and make the action like that of the Crossley engine, where timing of injection is depended upon to prevent detonating shocks.

These engines are real modern improvements. They can, with a comparatively moderate compression—200 to 350 lb.—give a fuel consumption that is substantially equal to the Diesel with its 450-lb. compression, but they must deal with a real difficulty. The combustion is essentially explosive combustion in fact or in type, and with explosive combustion not correctly timed—a little too early or too fast—detonations, either regular or intermittent, are almost sure. The shocks due to these detonations constitute one of the objections, and this has led other designers and investigators to devote their attention to different engines. Some of these others are of great interest. Together, they make up a new class of solid-injection Diesel engines with non-explosive combustion in cold walls, and each typical way of securing the result makes a new subclass.

An early attempt to eliminate the air compressor from the Diesel engine was made by the German, Hasselwader, as shown in Fig. 3, which is practically a Diesel engine with air injection but without a compressor. An open type of air spray is combined with the piston construction that has a cylindrical projection *A* trapping some air in the space *B*. A passage *C* leads this air around to the spray nozzle. The end of the piston supercompresses part of the charge of air, driving it over the fuel and causing it to deliver a spray of oil into the cylinder. The difficulty is, there is no control of timing. Any change in the leakage between the piston projection and the walls changes the timing,

*Part of an address before Boston Section, American Society Mechanical Engineers.

while carbon causes a binding action. There is also a tendency toward reverse flow on the out-stroke of the piston.

A modification of this, shown in Fig. 4, was the Korting-Trinkler engine. Trinkler had the piston and cylinder perfectly plain and also used the open spray nozzle. He added a little piston *A* in a cylinder connected with the main cylinder at both ends. Just at the right time the small piston *A* was moved by a cam control out so as to push air from the back and through the passage *B* to the spray nozzle. The little auxiliary piston made the charge of supercompressed air for spraying the fuel, and it was timed like the old make-and-break ignition of the gas engine. The objection was that the auxiliary piston often stuck and stopped the engine.

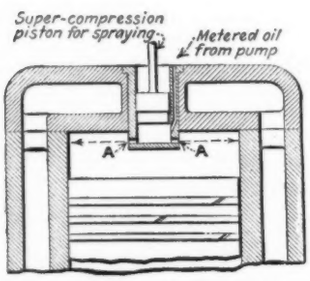


FIG. 5. HOFLINGER SUPER-COMPRESSION DEVICE

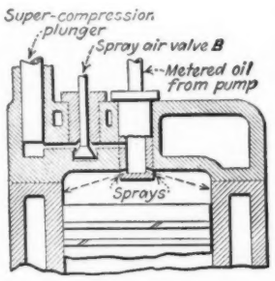


FIG. 6. GERMANDT SUPER-COMPRESSION DEVICE

The next suggestion is of an interesting sort, that of another German, Hoflinger, Fig. 5. A little cup-like cylinder with a piston projects into the cylinder. A passage for oil was connected below the piston, and before the fuel was wanted it was deposited by the pump in the cup, or bottom end of the cylinder. Just when it was wanted, a timing cam drove the piston down, compressing air on top of the fuel charge and expelling it through holes *A* in the side as an air and oil spray. So far as is known, this engine has not been built, but it is very suggestive, especially when you consider a very modern one, reported to have been developed at Detroit by Germandt, Fig. 6, with special reference to use for automobiles. This has the Hoflinger cup and fuel feed, but with a connection to a valve and to an auxiliary cylinder with a piston. The piston of Hoflinger's cup is replaced by an independent piston and a separate timing valve *B*. The plan of operation is that at the right time as the piston starts down, the valve opens and the charge of air is supplied to the cup, spraying the oil into the cylinder.

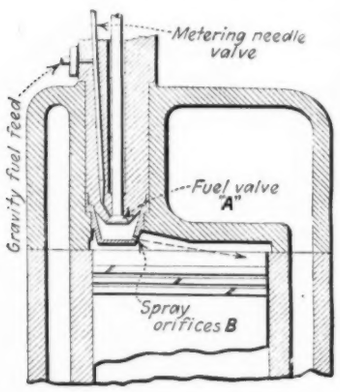


FIG. 7. HVID DESIGN OF CUP INJECTION

Finally, in this class the simplest of all and the one form that has come into general use for small stationary engines, is the Hvid of Fig. 7. This is a beautiful example of the importance and necessity for the utmost simplicity and corresponding clearness of fundamental principles. The Hvid engine is now the most widely built small injection oil engine and has practically no competition in its own field—farm units. The Hvid keeps the same fuel cup as the last two, but with entirely different connections for fuel and provisions for supplying and timing the spraying air. The fuel is delivered into the cup by gravity before compression begins, through a mechanically operated valve *A*, and after the fuel is in the cup it is a closed chamber. During compression air flows into the cup through three holes *B*, which prevent the outflow of oil prematurely, provided the holes are small enough to be capillary. After compression is complete, the air in the cup has a lesser pressure than in the cylinder, which differential is quickly equalized as soon as the piston passes dead center. As soon as cup pressure exceeds cylinder pressure, the cup air will spray the oil into the cylinder. If the holes are too large, fuel will leak into the cylinder while the cup is being charged. There is a limit to both number and size of holes, and the net result is that the Hvid cup seems to be limited to small cylinders, but in small cylinders where some number of capillary holes will pass the right amount of oil it is so far supreme. It is the simplest possible, automatic in timing because cylinder pressures control the spray, and the only objection is that combustion is a little late or slow. This little engine may be said to represent the limit of commercial success with solid injection supplied by air, without an air compressor for small engines.

Steinbecker has devised a spraying method that has been worked out experimentally. In the form shown in Fig. 8, a small bulb-like chamber with a narrow neck is connected to the cylinder head. Into the top of that chamber a spray nozzle projects and delivers a jet or coarse spray into the neck. At this time the air has already been compressed to and above the ignition temperature, so that as the oil sprays it immediately ignites, but not much can burn because not much of it can reach the air in the narrow passage. What burns on the back face of the spray, according to Steinbecker's idea, will raise the pressure in the bulb, so as to produce an outflow of gases to respray the oil which has been delivered to the neck and deposited on its walls. By the rise of pressure in the bulb Steinbecker expected really to spray the main charge of oil.

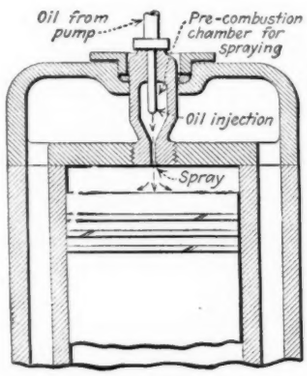


FIG. 8. STEINBECKER PRE-COMBUSTION GAS INJECTION

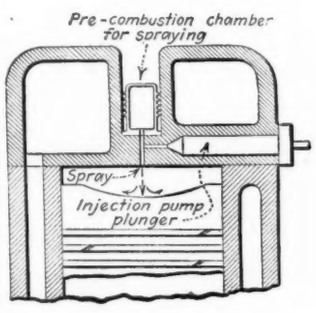


FIG. 9. LATER STEINBECKER COMBUSTION DEVICE

Steinbecker has a recent engine, Fig. 9, in which the bulb chamber is left, the neck passage made narrower —extremely narrow, so as to get a very high velocity

through it—and the injection pump delivery led into the middle of the neck. It is timed so that oil comes in near the end of the compression stroke while there is still some upward flow of air from the cylinder to carry the oil into the bulb chamber, which is unjacketed and hot, so as to produce ignition by explosion. The hot gases produce a reverse flow to the cylinder and

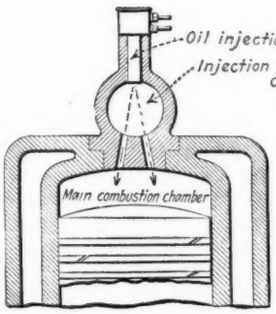


FIG. 10. NYDALL PRECOMBUSTION CHAMBER

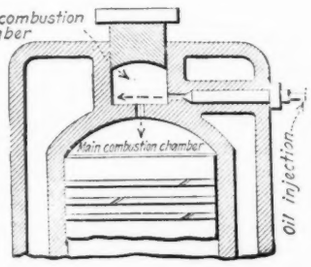


FIG. 11. NIELSEN PRECOMBUSTION CHAMBER

spray the oil delivered later directly into the cylinder. This is Steinbecker's engine as it now stands, as operated experimentally even in automobiles. The timing is directly by the pump, and should that pump throw the oil in too soon, there would be an explosive shock. If the timing is wrong, the correct amount of oil will not enter the bulb and the spraying will fail also. It is probably quite sensitive to pump timing, as is not the case with some others—the Hvid so far described, and others to be described later.

One of the great difficulties with injection is to prevent the development of explosive shocks by too early timing and loss of efficiency by too late combustion. Rapidly recurring detonations will wreck any machine. To direct the oil stream into the combustion chamber by a pump, without any other means of control of time and rate of combustion, is a method adopted by Vickers in England, using a central-pressure supply of oil admitted to spray valves by cam-timed oil valves. The equivalent was worked out by Junkers in Germany, who succeeded in making it work in an aircraft engine, and to him is due the credit of first making a solid-injection heavy-oil engine that would fly in the air.

In both cases, however, the German and the British, the fuel went directly into the cylinder and the production of detonating shocks was entirely a question of avoiding too early an injection. Since earliness and lateness is a matter of a few degrees of crank angle, they are extremely sensitive. To avoid the preignition or detonating shocks, the operator will usually set the valve too late. That means very slow combustion, and the difficulty in driving the fuel far enough and fine enough into the dense air to make combustion smokeless is very great, though it can be done.

Here a different principle, intended to prevent detonating shocks and relieve the engine of the necessity for accurate timing, claims attention. It offers possibilities of avoiding the difficulties discussed, that are most interesting. In accordance with it the main combustion chamber is divided into two parts—one part in the cylinder and one part removed—a divided combustion chamber. The compressed air is partly in the cylinder and partly in a connecting pocket, the major part being in the cylinder.

The first construction embodying this principle to be noted here, independent of dates, as no attempt is made to present the story chronologically, is a Scandinavian one by Nydahl, shown in Fig. 10. He provided a spherical chamber connected to a cylinder by a series of holes and with an oil spray at the top. The piston stops at a point that leaves considerable air in the cylinder. There is a body of air in the cylinder and there is another body of air in the injection chamber. If the air in the injection chamber is small enough in comparison with that in the cylinder, then when the fuel is injected into the combustion chamber, no explosive shock can occur, because the quantity of air is insufficient to burn all the oil. What, then, will happen to the rest of the fuel which does not unite with the air in the cup? It will change as it would in a gas producer where fuel reacts with less air than required for combustion. Nydahl proposed injection of water with the oil, as was common with the other different class of engines, but he certainly did show a structure in accord with this principle of the divided combustion chamber to prevent explosive shocks following injection. In this divided-combustion-chamber construction the piston becomes the principal element of combustion timing, somewhat as in the Hvid engine. The divided combustion chamber is the principal element of preventing the explosive shocks, the piston movement controls the completion of

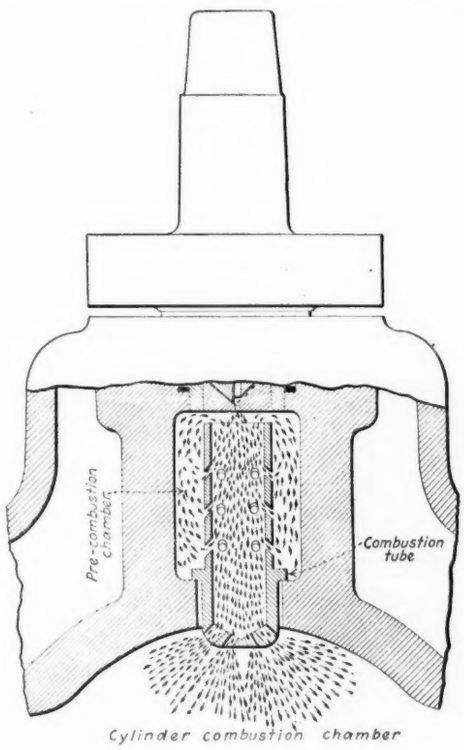


FIG. 12. LEISSNER DIVIDED COMBUSTION CHAMBER

combustion, and if the compression is high enough the whole combustion space can be jacketed.

Such a water-jacketed injection chamber, but of more or less cylindrical form, again with the divided-combustion-chamber idea, and side injection of fuel, is shown in Fig. 11. This is a Danish form, by Nielsen, who also provided for adjustment of injection-chamber volume by a special screw cover or cap.

Still another suggestion in the course of develop-

ment of the divided combustion chamber is the Leissner type, Fig. 12 which is now manufactured in the United States. Leissner adds to this Nydahl or Nielsen injection chamber, a tube that has holes in the sides, and a closed bottom also with holes to form the old-fashioned fuel distributor used with air and solid-injection spray valves. The Leissner tube comes up close to the injection spray nozzle, which delivers the oil inside the tube. Just as the small injection chamber alone prevents development of explosive shocks by limited contact of air and fuel, so does insertion of this tube here add something to limit the contact control. Leissner specifies that the holes through the bottom and sides of the tube and the space above it shall be so related to each other in area as to produce the following series of actions: Compression carried first to ignition temperature; injection into the tube in the injection chamber; partial combustion in the tube, producing a rise of pressure in the tube, which in turn projects jets of still unburned oil sidewise into the air around the tube. Combustion of these jets raises the pressure outside of the tube and causes reversal of flow back into the tube and down through it to the cylinder, helped by the movement of the piston. The air left around the tube finally passes through the tube and expels the fuel charge in front of it into the cylinder, the space around the tube and in the tube being in series.

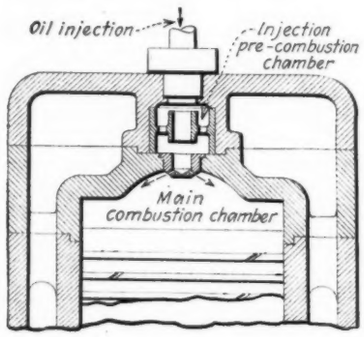


FIG. 13. WORTHINGTON COMBUSTION CHAMBER

Finally, in this class of divided-combustion-chamber injection engines there is a new one developed by Worthington—the class in which the injection or precombustion chamber is used to limit the development of explosive shocks and connected to the cylinder by an ejection orifice through which gasified fuel is expelled to the cylinder by a pressure differential, due partly to the movement of the piston and partly to the precombustion. This design is shown in Fig. 13.

A rise of pressure in the injection chamber, due to partial combustion, is supplemented by depression of the pressure on the cylinder side due to the piston movement, which starts the flow of parallel streams of air and fuel toward the cylinder. This action creates in effect a bunsen burner in the top of the cylinder. This arrangement gives a construction practically as simple and foolproof as the little Hvid, except for the injection pump, but one that seems to be adapted to a wider range of cylinder sizes and speeds and less limited by fuel quality.

The design shown is that of the first engines built. Experiments carried out by the Worthington engineers lead to modifications of the precombustion chamber, the shape of which, along with the diameter of the injection orifice, largely determines the engine's actions.

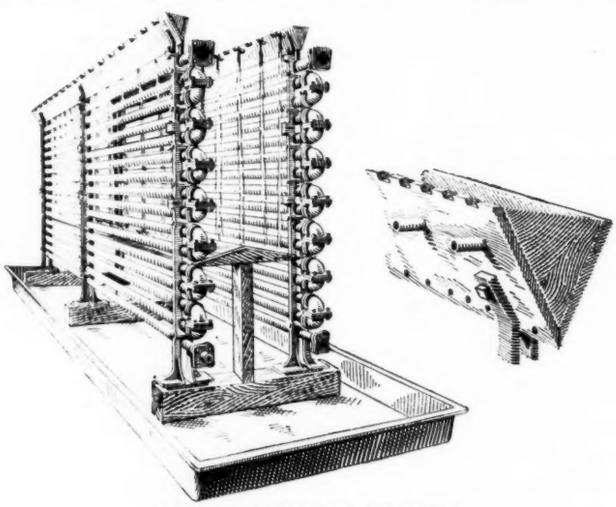
Water Trough for Atmospheric Ammonia Condensers

By J. R. Petrie

Refrigeration and ice-making companies have more or less difficulty with the condenser-water distributing troughs, owing to buckling, warping, rusting and misalignment. The majority of troughs are V-shaped, and are made of either galvanized iron or copper. When first installed these give good results, but after a period of from six months to a year they deteriorate, with the result that the cooling water is not distributed evenly. Where sea water is used for cooling, records show that galvanized iron troughs have to be renewed every 14 to 18 months, owing to corrosion.

All condensers gather and hold a certain amount of sediment, dirt, sand and foreign matter, depending on the water used, and have to be cleaned. During the cleaning, the troughs get out of line and are often left in this shape in the hurry to get the plant running. The water is not distributed evenly, leaving part of the pipes uncovered, and much of the water falls into the pan without touching the coils.

The writer devised the wood trough shown in the illustration, which eliminates these objections. The troughs are made of redwood lumber, and are fastened to the top of the condenser rack. The edges of the trough are notched, the water flowing down the side onto the upper condenser coils. In the majority of condensers the cooling water is quite warm by the time it reaches the lower coils. To overcome this difficulty, the trough is provided with a set of $\frac{3}{8}$-in. pipes, out of



NEW CONDENSER TROUGH

which water jets strike the splash boards and from there flow onto the lower set of coils. In this way the lower coils do as much if not more cooling than does the upper set. In one plant where these troughs are used, the increased cooling effect lowered the head pressure 10 lb. This design is not patented and is of great advantage in any plant where corrosion of galvanized troughs is bad, or where it is difficult to cool all the coils.

A Belgian engineer wants to dam the Congo, generate 2,000,000 hp. and transmit it over about 4,000 miles of cable to Gibraltar, where it would be available to supply all Europe. A sad case of hydroelectrolysis of the brain.

Locating Faults in Armature Windings—Single-Parallel Windings*

By B. A. BRIGGS

TROUBLES in direct-current armature windings may be classed as those which can occur during the period of winding and those which may develop after the machine has been put into service. In the former case the faults may be short-circuits, open-circuits, cross-connected coils, reverse coils, and grounds, while in the latter the faults are usually limited to short-circuit of one or more coils, open-circuits and grounded coils.

The effect produced by these faults (as pointed out in the previous article in the Sept. 6th issue) will depend to some extent upon conditions. In this article will be discussed the effects of open-circuits in armature windings and the effects obtained.

Fig. 1 shows a 24-coil winding connected single-parallel for a 4-pole machine. The coils are made up of a number of turns of comparatively small wire, formed to the proper shape and insulated with tape before being placed in the slots. If the winding were cut from the page and the two ends turned under and brought together to form a ring, the sides of the coils *A*, *B*, *C*, *D*, *E* and *F*, which are now on the right, would fall into slots *A'*, *B'*, *C'*, *D'*, *E'* and *F'*, now on the left. Therefore, the figure gives a clear picture of the winding as it would be in an actual machine. Since this winding is connected single-parallel for four poles, four sets of brushes are required on the commutator, spaced 90 deg. apart. The polepieces are designated by the rectangles shown in dotted lines and are assumed to be on the outside of the armature core; consequently the lines of force from the *N* poles will be down through the plane of the paper and those from the *S* poles will be up through the paper. Now, if the armature is moved in the direction of the arrow *K*, the direction of the voltage produced in the coils will be that of the arrows shown on the windings. Since the machine is considered as a generator the flow of the current through the windings will be from the negative to the positive brushes.

Starting from the negative brush on commutator segment *1*, there are two paths, one through lead *a* and another through lead *b*. First taking the path through *a*, this follows around through coil *1* to commutator segment *2*, then through coils *2*, *3*, *4*, *5* and *6*, until segment *7* is reached, on which one of the positive brushes rests. From this brush the circuit is completed through the external load back to the brush on segment *1*.

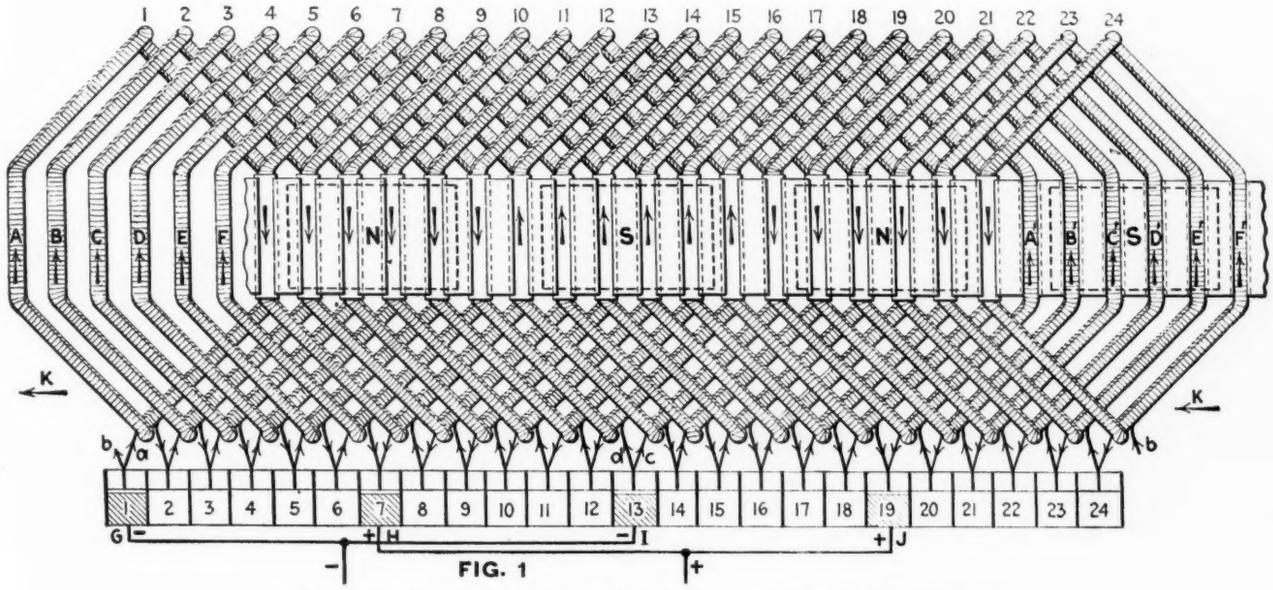


FIG. 1. DIAGRAM OF A 4-POLE 24-COIL SINGLE-PARALLEL WINDING

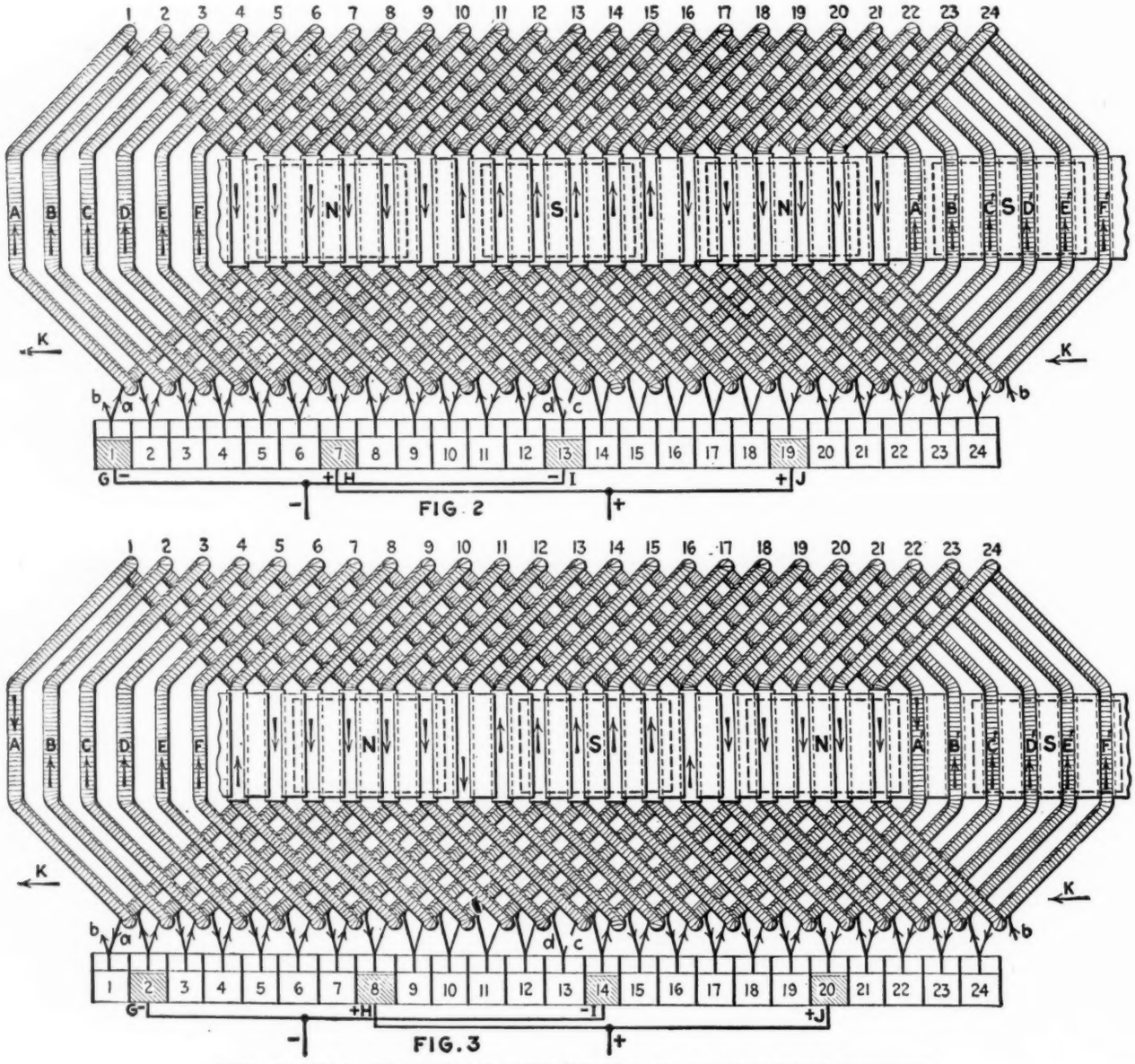
There is a second path through the winding from segment *1*, namely, through *b*. Part of this lead is found connected to segment *1* on the left and the other part on the right connected to coil *24*. This is as it should be since, if the winding were rolled up in the form of a ring, as on an actual armature, coil *24* would be alongside coil *1*. The circuit through the windings from *b* is through coils *24*, *23*, *22*, *21*, *20* and *19* to the positive brush *J* on segment *19*. From this brush the path of the current is completed through the load to the negative brush *G* on segment *1*. From the negative brush *I* on segment *13* there are two other paths through the coils. One of these is through lead *c* and coils *13*, *14*, *15*, *16*, *17* and *18* to the positive brush on segment *19*. The current flowing in this path completes the circuit through the external load to the negative brush on segment *13*. The fourth path through the winding is from lead *d* through coils *12*, *11*, *10*, *9*, *8* and *7* to the positive brush on segment *7* and through the load back to negative brush on segment *13*. In all four circuits it will be noted that the direction of the circuits through the winding conforms to the direc-

*All rights reserved.

tion of voltage indicated by the arrows on the coils. Furthermore it will be observed that there is a circuit through the winding for each pole. This is true in all cases for a single-parallel winding.

If coil lead *c* were to become broken from the commutator segment *13* as in Fig. 2, then there would be three paths only through the winding as shown in the figure. Voltage would be generated in coils *13*, *14*, *15*, *16*, *17* and *18*, as in Fig. 1, but no current can flow on account of the open in lead *c*.

Assume that the armature revolves through the part of a revolution equal to one commutator segment; then the brushes will rest on segments *2*, *8*; *14* and *20* as in Fig. 3. Now we find that the path in the armature circuit is open through coils *13*, *12*, *11*, *10*, *9* and *8*. In Fig. 2 current was flowing through the armature from negative brush *I* to positive brush *H*, but in Fig. 3 the path is from *I* to *J*. This means a complete reversal of the current in this part of the armature. If the machine were operating under full load when this occurred then, as segment *13* passed out from under brush *I*, the circuit from *I* to *J* would be broken with full-load current flowing. As a result a heavy arc would be created, just as when a switch is opened in a circuit under load. In an armature this circuit is opened every time the segments to which the faulty coil is connected passes a brush, in this case, every time segments *13* and *14* pass a brush, or, four times per revolution. If the machine is running 500 r.p.m. only, then the circuit is opened $500 \times 4 = 2{,}000$ times per minute. Therefore, it can be readily seen why an open-circuit in an armature will cause severe burning between the segments to which the defective coil is connected, in this case segments *13* and *14*.



FIGS. 2 AND 3. EFFECTS OF OPEN-CIRCUIT IN AN ARMATURE WINDING

If the machine is operating under light load the sparking may be of little consequence, but under heavy-load conditions it is severe and if the machine is allowed to operate for an hour or two under such conditions, the commutator will be badly burned between the segments to which the defective coils are con-

nected. This arcing in large machines operating under heavy load may cause a flash-over between brushes and open the circuit breaker. Where machines are operating under light load the sparking may not be noticeable.

One of the most common places for an open-circuit to occur is where the leads connect to the commutator. However, the open may occur in any part of the coil. But wherever it occurs and whatever the cause the effect is the same. In some cases, owing to poor soldering of the leads to the commutator, one or more may make poor contact. This may not cause severe sparking but only blackening of the segments to which the defective connections are made.

A complete repair of an open circuit in a coil requires removing the coil from the armature and replacing it with a new one. If one of the leads from a coil is broken then the defective lead may be located and repaired without removing any coils. All that will be necessary is to lift some of the leads out of the commutator to get at the defective one.

When an open-circuit occurs in an armature, what is called a temporary repair can be made, although it generally turns out to be a permanent one in practice. This consists of connecting together the two segments to which the defective coil connects. With an open circuit in coil *13*, as in Figs. 2 and 3, a burn on the commutator would occur between segments *13* and *14*; therefore, these two segments would be connected with a jumper as in Fig. 4. There are a number of ways of connecting the segments together, a rough-and-ready means being to cut a little of the mica from between the segments at the out corner of the commutator and swedge the adjacent corners of the two segments together. However, this should not be done unless it is necessary to get the machine back into service as soon as possible, since it leaves a bad looking spot on the commutator. Another method is to solder the two segments together at the back of the commutator where the leads connect, the solder being run across from one segment to another over the mica insulation. It will be noted that connecting segments *13* and *14* together completes the circuits through the winding, but instead of being through coil *13* it is from segment *14* to *13* direct.

There is always danger of the open-circuit in the coil closing when the machine is in operation and if this were to happen when the circuit is closed between the two segments to which the coil connects, then the latter would be short-circuited and would burn out and probably injure other coils in the winding, and make repairs or a complete rewinding of the armature necessary. To prevent this the top leads connecting to the segments between which the burn occurs should be lifted and the defective coil located by testing with a lamp. For example, if there were an open-circuit in coil *20*, Fig. 4, then with the machine in operation a burned spot would occur between segments *20* and *21*. To find the dead coil, unsolder the top leads from segments *20* and *21* and then, with a test lamp, place one test connection on, say lead *21*, and with the other try on the segments for a light. In this case a light will be obtained from segment *22* to lead *21*, since this coil is not defective. If the test lead is placed on segment *21* no light will be obtained because the other lead of coil *21* connects to segment *22*. With one test lamp terminal on lead *20* and the other on segment *21*, even if the other lead of coil *20* connects to this segment, no light will be obtained because there is an open-circuit in the coil. The lamp's failure to light would indicate the defective coil. Then lead *21* may be soldered back into segment *21* and the end of lead *20* bent back clear of the commutator, segments *20* and *21* connected together with a jumper, and lead *20* taped up and bound down with the leads from the other coils. Under this condition even if the open in the coil were to close no harm would result, since the coil is permanently open at segment *20*.

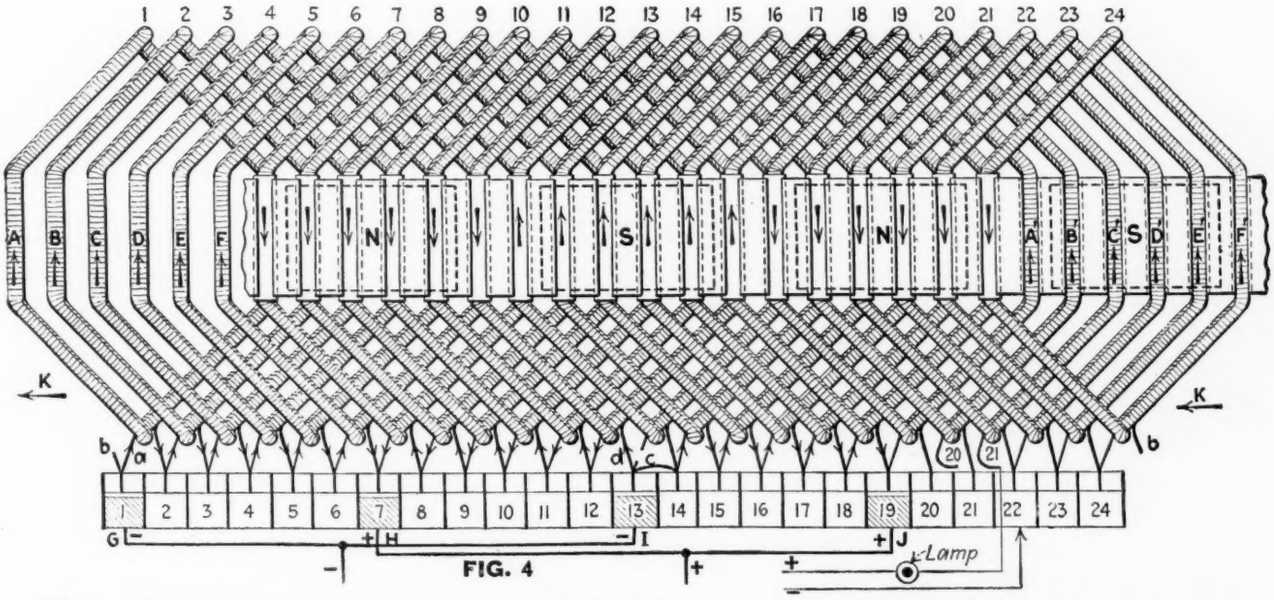


FIG. 4. METHOD OF LOCATING OPEN COIL WITH TEST LAMP—DEFECTIVE COIL BRIDGED OUT OF CIRCUIT

There is a method in general use for locating the defective coil without unsoldering any leads from the commutator, by the use of a low reading voltmeter or a telephone receiver. This method will be considered in another article. The foregoing discussion applies to a single-parallel winding only. The next article will deal with open-circuits in single-series windings.

Power Plant Accounts—IV. Indirect Expense

By WILFRED A. MILLER

ORDINARILY, many more elements enter into a cost than a mere cursory examination would indicate. Thus, suppose that we propound the question, How much does it cost to have a collar laundered, if the laundry charges four cents per collar? On the face of it the question looks too simple to bother with. If the laundry charges four cents, how can the cost be anything but that? Let us examine the question a little more critically. It is true that we pay the laundry four cents and nothing more. But is that the only element of cost to us? From experience we know that a collar can be laundered only a limited number of times before the linen breaks so badly that it must be discarded. Let us assume that a collar can be laundered 25 times before it becomes useless. It is evident then that every time it is laundered $\frac{1}{25}$ part of its value is gone. If the collar cost 25 cents to buy, we lose $\frac{1}{25} \times 25 = 1$ cent, every time we send it to be laundered. Hence, the cost of laundering is not merely the four cents the laundry charges us, but also the one cent loss of collar that inevitably accompanies the laundering. Thus, we have, cost of laundering one collar $= 4 + 1 = 5$ cents. Similarly, if we should be required, for example, to figure the cost per horsepower-hour, of the power delivered by an engine, we might carefully determine the number of pounds of coal and water per horsepower-hour, the amount of wages per horsepower-hour, and even the value of the oil, etc., used, and yet we would not have the total cost. One of the things that we would not have considered would be the "amount of engine" that is "used up" for each horsepower-hour that is turned out. Just as a certain amount of collar is used up every time we send it to the laundry, so a certain amount of engine is used up for every horsepower-hour we take out of it. Thus, if an engine cost $5,000 when new, and we expect that it will wear out in 25 years, we must allow $\frac{5,000}{25} = \$200$ per year for wear of the engine. Then, if in the course of a year it has delivered, let us say, 1,000,000 horsepower-hours, we have $\frac{200}{1,000,000} = \$0.0002$, or $\frac{1}{50}$ cent, as the amount of engine wear that must be included in the cost of each horsepower-hour delivered. This example will serve to illustrate the point that elements of cost exist that are not readily recognizable at first glance, and consequently will bring home the necessity of making an analysis of what really constitutes cost of power.

In previous articles we decided to divide the elements of power cost into the following classes: (1) labor; (2) fuel; (3) water; (4) lubricants; (5) ash removal; (6) repairs; (7) scale removal; (8) miscellaneous supplies; (9) investment. It will be remembered that the ninth item—Investment—is listed with the others only as a matter of convenience, but that it is not to be considered as an item of cost. Upon investigating the remainder of the list, we will look in vain for any class of expense to which to charge the depreciation, or using up, of the engine about which we have just been speaking. It is here that we must consent to be introduced to a new tribe of charges whose acquaintance we may make under the name of "Indirect Expenses." A representative member of this tribe is the one we have just been speaking about; namely, "Depreciation." We shall become better acquainted with the others as they make their appearance upon the scene.

Before submerging ourselves in a study of this newcomer, let us find out why his tribe is named "Indirect Expense." To do this we must hark back to our first classification of accounts; namely, labor, fuel, water, etc. It is clear that these items are the ones that enter directly into the generation of power. Therefore, we call them the "Direct Expenses." Those other expenses, like "Depreciation," which do not appear on the face of things, but which must nevertheless be dug out of their hiding places and brought to book, are distinguished from the "Direct Expenses" by calling them "Indirect Expenses." If we were now to divide our accounts into their most general subdivisions, we would have: (a) Direct Expenses; (b) Indirect Expenses; (c) Investment. Each of these groups would be composed of a number of elements, which would cause a complete tabulation to take a form somewhat like the one herewith:

(a) Direct Expenses:
1. Labor
2. Fuel
3. Water
4. Lubricants
5. Ash removal
6. Repairs
7. Scale removal
8. Miscellaneous supplies

(b) Indirect Expenses:
1. Depreciation
2. .....
.....

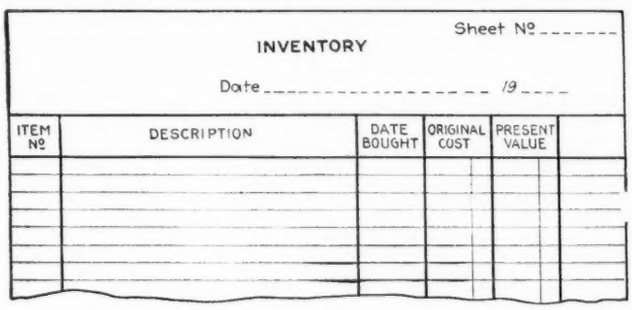
(c) Investment:
1. Steam engines
2. Steam pumps
3. .....

Each of the groups (a), (b) and (c) might have a single account in the ledger for gathering together all the charges of each kind, but it will be remembered that we found it better suited to our purposes to have a separate account for each of the items that constitute group (a). In the case of group (c), however, we used only one account for all investment items, and the same procedure will be satisfactory for the present in our treatment of group (b), namely, the "Indirect Expenses," so that we shall be called upon to deal with only one new account.

From the foregoing it will have become apparent

This is the fourth of a series of articles written in conversational style and treating the subject of power-plant accounts in a thorough, yet extremely simple manner. They were prepared primarily for the guidance of the operating engineer who wants to keep track of the cost of the power he is making, but who knows nothing at all about bookkeeping. Others may find these articles helpful in clearing up their ideas on the subject. This installment starts by reviewing part of what has gone before and then takes up the subject of depreciation as an item of indirect expense.

that we must add a new account to the ones already in our ledger. Having chosen a page in the ledger for the purpose, we write the title of the new account at the top of the page and then make a memorandum of the name and the corresponding page number in the index that we have presumably already started in the front of the ledger. Having prepared a resting place for the "Indirect Expenses," the next question is, How are we going to get at them? That they must first be entered in our journal and from there be posted to the ledger is a foregone conclusion, but where are we going to obtain journal entries? Here is where we are called upon to use our ingenuity and judgment. There will be quite a number of different members of the tribe "Indirect Expense" to be considered, but for the present we shall devote ourselves to cultivating the more intimate acquaintance of only one of them, and that one will be our friend, "Depreciation." Although we have so far mentioned only "Depreciation of Steam Engine," we must know that he has a lot of cousins, some of whose


INVENTORY

Sheet No._____

Date_____ 19____

ITEM No	DESCRIPTION	DATE BOUGHT	ORIGINAL COST	PRESENT VALUE	

FORM FOR APPRAISAL OF EQUIPMENT

names are Depreciation of Boilers, of Pumps, of Generators, of Buildings, etc. In fact, everything connected with the power house except the ground on which it stands, is depreciating all the time, and we must take all these different kinds of depreciation into account.

It is quite a job to make the first determination, but once it has been made, there is not much trouble about applying the various charges. What is really required is an "appraisal" of our entire equipment. That is, we must go over it piece by piece and determine how much each part is worth. The best way is to prepare a number of sheets of paper, ruled with columns, like the form shown in the figure. The items can be numbered from 1 up. Giving each a number makes reference a simple matter. These numbers are entered in the first column. In the second is entered a description of the apparatus inventoried, in the third the year in which it was purchased if this is known or can be determined. In the remaining two columns are entered the cost of the apparatus when new and its present value. It is, of course, often impossible to determine the original cost of an item, and in that case no entry of it can be made. In many cases, however, the original bills can be dug up for the purpose. When the original value is known, the present value can be arrived at by deducting the amount of depreciation for the time the apparatus has been in use. How to apply this depreciation will be explained presently. When the original cost cannot be determined, there is nothing for us to do except make a good guess as to what the present value is and enter this amount in the "Present Value" column. This is what professional appraisers do, and while our guess may not be quite as dependable as theirs, it will serve our purpose perfectly for the present.

Now, to illustrate how we may apply depreciation to the various items that we have inventoried, let us go back to a consideration of the steam engine we mentioned when we were discussing the question of how much it costs to launder a collar. In the example we assumed that the engine would wear out in 25 years and that the amount of depreciation each year would therefore be $\frac{5,000}{25} = \$200$. Instead of dividing the depreciation in equal amounts over the assumed period —in our case 25 years—another method may be pursued which is really more equitable. In the method described we deducted each year $\frac{1}{25}$ of the original cost of the engine. Since $\frac{1}{25} = 0.04$ or 4 per cent, we see that we deducted 4 per cent of the "new" value each year. Thus we would have the values given in column (*a*) of the table.

Now, instead of deducting 4 per cent of the new value each year, let us assume a method by which we would deduct 10 per cent each year from the value at the beginning of that year. For example, after the first year we would deduct 10 per cent of the new value, or 10 per cent of $5,000, giving a reduction of $500 and bringing the value at the end of the first year to 5,000 — 500 = $4,500, instead of $4,800, as would be obtained by the 4 per cent method. At the end of the second year we deduct 10 per cent of the value at the beginning of the year, namely, $4,500, so that we would have 10 per cent of $4,500 = $450, which deducted from the value at the beginning of that year would give us 4,500 — 450 = $4,050 as the value at the end of the second year instead of $4,600 by the 4 per cent method. The values from year to year as obtained by the 10 per cent method are given in column (*b*) of the table,

COMPARISON OF TWO METHODS OF FIGURING DEPRECIATION

Years in Use	(*a*) Value of Engine at a Depreciation of 4 per Cent per Year on Cost Price	(*b*) Value of Engine at a Depreciation of 10 per Cent per Year on Yearly Value
New	$5,000.00	$5,000.00
1	4,800.00	4,500.00
2	4,600.00	4,050.00
3	4,400.00	3,645.00
4	4,200.00	3,280.50
5	4,000.00	2,952.45
6	3,800.00	2,657.20
7	3,600.00	2,391.48
8	3,400.00	2,152.33
9	3,200.00	1,937.10
10	3,000.00	1,743.39
11	2,800.00	1,569.05
12	2,600.00	1,412.14
13	2,400.00	1,270.93
14	2,200.00	1,143.84
15	2,000.00	1,029.46
16	1,800.00	926.51
17	1,600.00	833.86
18	1,400.00	750.47
19	1,200.00	675.42
20	1,000.00	607.88
21	800.00	547.09
22	600.00	492.38
23	400.00	443.14
24	200.00	398.83
25	None	358.95

and from a comparison of columns (*a*) and (*b*) it is seen that the values in (*b*) are all lower than those in column (*a*) until the engine has been in use 23 years, when the values in column (*b*) become greater than those in (*a*). It is readily understood that the value in column (*b*) can never reach zero, although as the years go on it will become very small.

From a practical standpoint it is evident that the value of the engine will never be zero, since there will always be at least its value as scrap. Moreover, it will be noted that, by the method that uses percentage of the

new value as a basis of figuring depreciation, the drop in value as the years go on becomes very great. Thus between the 23rd and 24th years the value drops from $400 to $200; that is, it is cut right in half. By the method that reduces the value by a percentage of the yearly value, the percentage decrease in any one year is always the same as in any other—in our case 10 per cent. There are still other ways of looking at the matter of value of equipment, but the foregoing examples will serve to illustrate the fact that the problem of depreciation must be met and that it may be met in different ways. No matter what the method, a certain yearly deduction in the value of the engine must be made, and of course what applies to the engine applies to all the apparatus in the plant. Making this deduction is often referred to as "writing-off" a certain amount of the value.

The methods presented show how the yearly depreciation may be computed. If we wish to obtain the cost of the power generated month by month, we shall of course be compelled to divide the yearly depreciation by 12 in order to find out how much to charge each month. Having done so, we make an entry in our journal under the classification "Indirect Expense" and enter the amount in the left hand column. Then this entry is posted to the ledger, as are all others. In making our "Indirect Expense" entry for depreciation, it is not necessary to make an entry for each piece of apparatus. This would require a multitude of entries every month and merely clutter up the books with a constant repetition of the same items. One entry each month for all the items of depreciation bunched together will serve the purpose equally well and will dispense with a vast amount of detail work. The final figure obtained for the cost of power will be the same as if one entry were made for the depreciation of each engine or turbine, one for each boiler, and so on, for every piece of equipment in the plant.

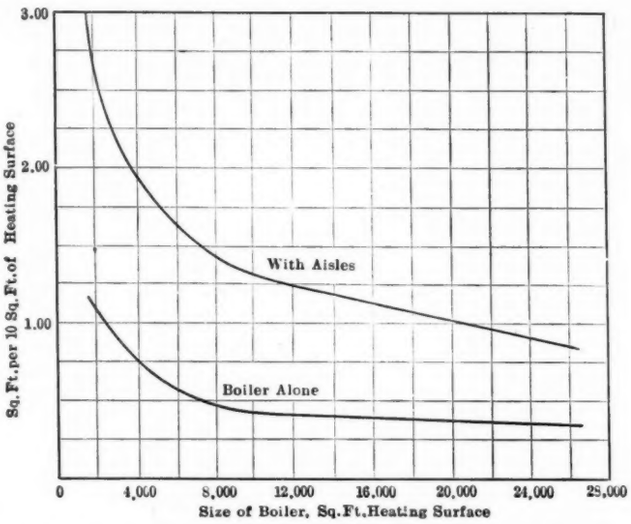
Boiler-Floor Space

By J. B. Crane

The accompanying table and the curve give the square feet of floor space per 10 sq.ft. of boiler heating surface occupied by vertical water-tube boilers. These data will also apply very closely to horizontal water-tube boilers, with the exception that in the smaller sizes the floor space per 10 sq.ft. of heating surface will be slightly increased.

The table shows the space occupied both with and without aisles and also indicates the size aisle assumed in this particular case. Of course this will vary with the local conditions and with the ideas of different engineers, but the figures shown will not appreciably change.

Preliminary designs were recently worked out for a 60,000-sq.ft. boiler and showed a floor space for the boiler alone of 0.25 sq.ft. per 10 sq.ft. of heating surface. To operate boilers at 200 per cent of rating continuously, it has been customary to install approximately 0.20 sq.ft. of grate surface per 10 sq.ft. of heating surface, and this can readily be done in boilers up to 10,000 sq.ft. in size. However, in units of 10,000 sq.ft. heating surface and upward it is considered good engineering to provide enough grate area to operate at 300 per cent of rating continuously and to carry 400 per cent of rating at times, and it is therefore necessary to have at least 0.30 sq.ft. of grate area per 10 sq.ft. of heating surface. In sizes above 20,000 sq.ft there is not enough floor space under the boiler to put in grates of this size. In case it is desired to use stokers, it is necessary to install extensions to the boiler with dutch ovens. If the decreased floor space made available by large boilers is to be taken advantage of, it is therefore necessary to consider some other method of providing the requisite amount of hot gases, and at this writing the burning of powdered coal seems to be the best method available. In a recent installation of 26,500 sq.ft. in boiler-heating surface, powdered bituminous coal has been in operation for several months,



FLOOR SPACE OCCUPIED BY VERTICAL WATER-TUBE BOILERS SINGLE SETTING

and the results show that this method of taking care of the supply of the requisite amount of hot gases offers the most reliable and economical arrangement possible.

There is, therefore, no reason why boilers of up to 60,000 sq.ft. of heating surface cannot be built, and with the construction of some of the superpower plants contemplated, it is quite possible that units of this size will be installed.

Two boilers of this size, operating at 185 per cent of rating will supply sufficient steam to operate a 60,000-kw. unit and in case of emergency one boiler can take care of a unit of this size. With the use of distilled water and modern methods of boiler-house operation, with trained men and instruments to know what is being done, a boiler becomes as reliable as the turbine. The man who does not believe in putting too many eggs in one basket will still continue to install a multitude of boilers and other equipment with all their attendant troubles, but the man who believes in putting all his eggs in one basket and then watching the basket will continue to blaze the way to new and better methods, as he has done in the past.

FLOOR SPACE DATA, VERTICAL WATER-TUBE BOILERS

Sq. Ft. per 10 Sq. Ft. Heating Surface

Approximate Size, Sq. Ft. Ht. Surface	Single Setting Boiler Alone	Battery Setting Boiler Alone	Single Setting With Aisles	Battery Setting With Aisles	Width of Aisles Front	Rear	Side
1,500	1.15	1.12	3.06	2.86	10	6	6
3,000	0.93	0.92	2.42	2.05	10	6	6
6,000	0.60	0.58	1.57	1.14	10	6	8
10 000	0.43	....	1.32	....	10	10	10
26,500	0.34	....	0.85	....	10	10	15

Above 6,000 sq.ft. and in many cases above 5,000 sq.ft. of heating surface, the boilers are installed in single settings in order to take care of the fires better.

The Merit Automatic Oil-Stoking System

A Description of the System as Adapted to a Mechanical Type of Burner

THIS control system, a product of the Associated Engineering and Supply Company of San Francisco, was originally designed to be used with steam atomizing burners. It has been extensively used on the Pacific Coast for several years with this type of burner and was recently introduced in the East for use with both steam and mechanical atomizing burners.

The underlying features of this system is that it will automatically carry the fires through a variation of load ranging from the smallest fires possible to maximum boiler capacity and reverse, with high efficiency and minimum attention.

This is accomplished with separate adjustments for each fire by controlling the oil pressure to the burners, the flue dampers and the speed of forced- and induced-draft fans, when used, in a series of predetermined steps. It is the usual practice to regulate the fires in three such steps giving the range of boiler rating desired. In some installations the base load is definitely assigned to a certain number of boilers, manually operated at their most efficient rating and the variations in load taken care of by as few boilers as possible, automatically controlled. Where all boilers are automatically controlled, the variations in load are uniformly distributed among all boilers with practically the same over-all efficiency as with the foregoing method.

Fig. 1 is a typical layout for this system as adapted to the mechanical type of burner and installed in the power plant of the Fall River Electric Light Co., Fall River, Mass., applied to one battery of boilers, providing for the control of fires in a series of three steps. The equipment in this case consists of a master controller set governing a damper interlocking device and an interlocking device for forced-draft fan control, these two devices being identical in construction. The master controller set is divided into two elements, one governing the intermediate fire and the other, the maximum fire, step No. 1 or small fire being manually adjusted for any predetermined rating. The damper and fan interlocking devices are similarly divided and connected by control piping to corresponding elements of the master controller set.

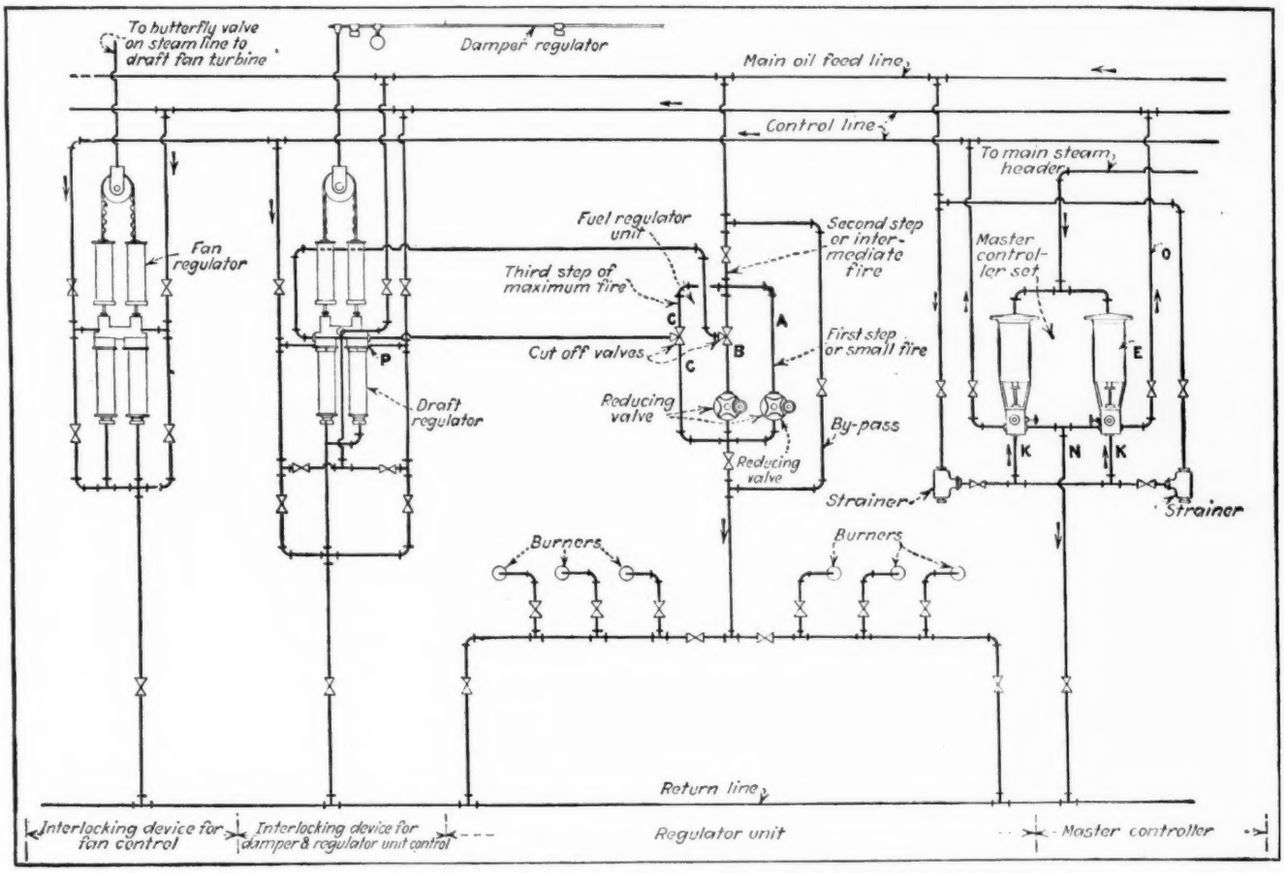


FIG. 1. DIAGRAMMATIC LAYOUT OF MERIT AUTOMATIC OIL-BURNING SYSTEM

The damper interlocking device, in addition to opening and closing the damper, operates cutoff valves in the corresponding lines of the regulator unit. Views of the master controller set and damper interlocking device are shown in Fig. 2 and Fig. 3 respectively.

Considering the three-step method already mentioned —namely, the small fire or step No. 1 to handle the minimum load, the intermediate fire or step No. 2 for medium load, and the maximum fire or step No. 3 for maximum load—it is necessary in starting up the sys-

tem to make manual adjustments of the dampers, forced-draft fans and oil pressure to give maximum efficiency at each of these chosen ratings. After these adjustments are once made, the control system will automatically carry the fires from No. 1 to No. 3 and reverse with an exact duplication of the manually made adjustments, as often as the demand for steam requires.

As the pressure at which complete atomization is obtained with mechanical burners is quite definitely established, there is a certain minimum rating for step No. 1 with all burners on. When a lower rating is desired, it is possible to cut out individual burners with a resulting drop in efficiency; better practice is to cut out an entire boiler and allow the remaining ones to fluctuate between steps No. 1 and No. 2. The maximum fire is determined by the rating at which load conditions require the boilers to be operated.

Referring to the regulator unit in Fig. 1, the right-hand branch *A* is equipped with a reducing valve which governs the oil pressure for the small fire; the middle line *B*, with a reducing and automatic cutoff valve, governs the intermediate fire, while the left-hand branch *C*, carrying full pump pressure, with an automatic cutoff valve, governs maximum fire. On boilers not capable of taking full pump pressure, reducing valves are also

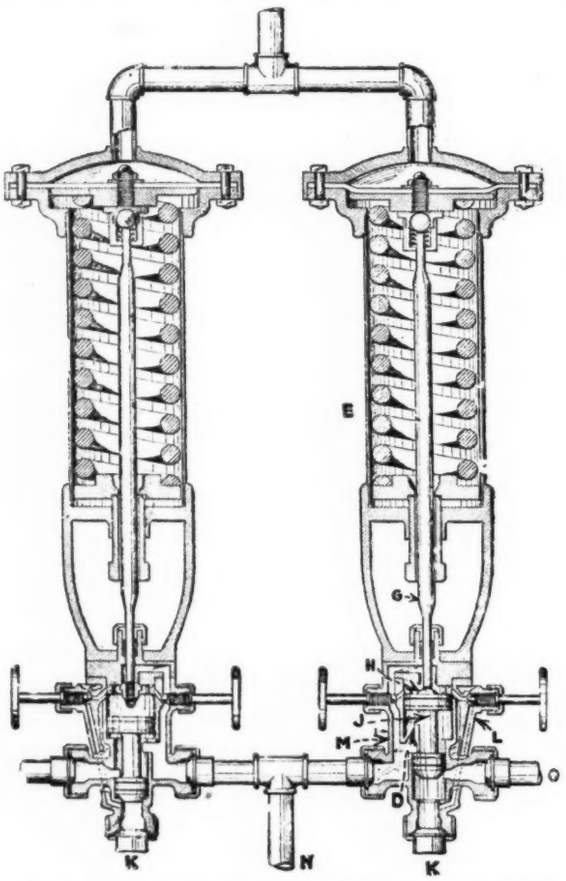


FIG. 2. CROSS-SECTION OF MASTER CONTROLLER

used in the maximum fire line. The master controller set is operated by variations in the steam pressure through a connection to the main steam header. Assume that the small fire is burning and that the right-hand element *E* of the control apparatus, Figs. 1 and 2, governs the intermediate fire. When there is a drop in steam pressure, the operation of the control apparatus to put on the intermediate fire is as follows: The decreased steam pressure in the steam chamber above the diaphragm of this element of the master controller allows the spring to move the rod *G* upward. The end of this rod carries a valve which now seats and prevents the oil which is constantly flowing up *K* and the bypass *L* from escaping down the return bypass *M* and the return line *N*. The main oil-line pressure now acts on top of the differential piston *J*, shifting it downward to the position shown in the left-hand element of the controller. In this new position the oil from the corresponding side of the damper and fan device is released, passing through pipe *O* around the differential piston *J* and down the pipe *N*. As will be seen in Fig. 1, this oil is released at *P* from the upper side of the pistons of the devices, allowing the weights to carry the piston upward to the position shown in the left-hand side of Fig. 3, and in so doing opens the flue damper and speeds up the fan. In addition to operating the damper, the piston valve of the damper interlocking device at the end of its travel uncovers ports which release the oil pressure in the control pipe to the corresponding cutoff valve in the regulator unit. This release of oil pressure opens the cutoff valve, and oil is admitted through the reducing valve to the burners at intermediate fire pressure.

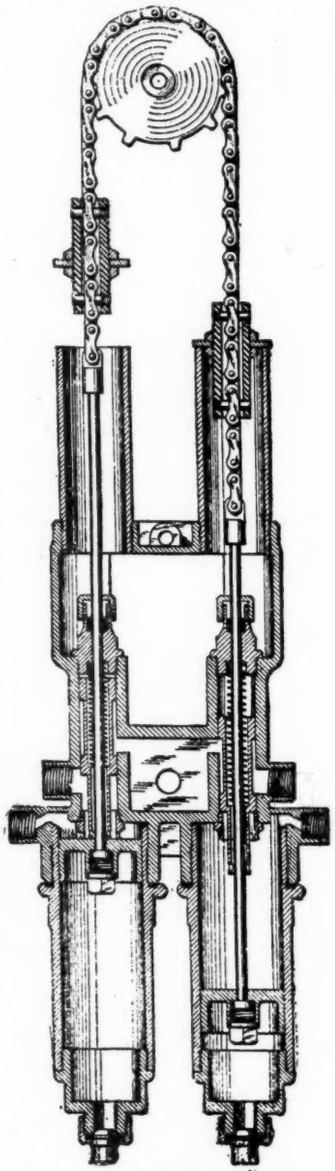


FIG. 3. CROSS-SECTION OF FAN AND DAMPER CONTROL

If the steam pressure in the main drops still further, the element of the master controller set for maximum fires operates, and corresponding elements of the other devices go through a cycle similar to those for the intermediate fire, and oil at full pump pressure is admitted to the burners.

On the reverse cycle the operation is just the opposite. In stepping up the fires, the damper must open and the fan speed up momentarily before the oil pressure is increased, while in stepping down, the damper remains open and the fan speeds up for a like period after the oil pressure is decreased.

The damper being weighted to hold it open, except when controlled by the automatic system, is in reality a safety feature.

EDITORIALS

Introducing the Human Element

HUMAN interest or personal touch has been sadly neglected in many dealings with power plants and power-plant apparatus; this is one reason why, perhaps, so many are operated as they are, why the operating force so often fails to receive the recognition accorded other workers and why the power plant is too often a thing apart. Perhaps the engineers themselves are largely to blame for this. The work of the power plant necessarily serves to isolate its workers; the functioning of the plant is such that only those most closely in touch with its *modus operandi* appreciate and understand them. As a consequence it is left to itself because the factory or organization managements know little about it and because the power-plant personnel, as a rule make little or no effort to make themselves or their work known.

A trip was recently made through a factory in company with the president, who prided himself upon the extent to which he had introduced the human interest or personal touch in his organization. A cafeteria and rest rooms for the employees had been provided; there was a tennis club, a mutual benefit association, group insurance, a visiting nurse and similar welfare activities to show that the employer had the interest of the employees at heart. Working conditions were good, including ample light, generous ventilation, individual lockers, shower baths, etc. A form of employees' representation had been adopted, as showing, further, that human interest and personal contact are vital phases of present-day industrialism.

After the inspection of the factory, and on the way back to the office, the president was asked why he had not shown the power plant—the heart of the establishment. He replied that he had forgotten about it, he rarely visited it, because it was hardly part of the factory proper and was so troublesome anyway.

As might be surmised from the remarks made, the plant had never had much of a chance any more than had its personnel. The boiler room was dark and cramped, apparatus was run down, and the whole place looked uncomfortable. Doubtless, performance was in keeping with environment. There was nowhere for the men to sit down and rest and reason things out, notwithstanding that the modern plant requires brain more than it does brawn. There was no adequate place for the men to change their clothes, or wash. There was no special place to eat. There was nothing to make the plant fit for human habitation or encourage good work.

"How is it," the president was asked, "that you have carried your employees' welfare so far in your factory and yet apparently have done nothing in the same direction in your power plant?" "Oh," he said, "it is pretty difficult to do anything here, because these fellows are hard to please. They do not seem to mix with the rest of the employees and anyway, I hardly consider this part of the plant."

This little incident holds true for numerous plants—and the more's the pity. The management does not think; it divorces its power plant from the rest of the establishment notwithstanding that the entire works depends upon the functioning of the power plant and the loyalty of its workers.

The engineer who obtains the viewpoint of those that must pass on his suggestions is more likely to "sell" his ideas than the one who sees only his own viewpoint. There are different ways of explaining a thing, and very often the less technical it is the better. Introduce the personal element, or human interest.

Insist on being "one of the boys" when it comes to employees' welfare. If the company issues a house organ, make it a point to have brief mention of the power plant, what it is doing and who comprise the personnel. It pays to advertise. A little insistent publicity in a legitimate way, telling of the good work the men are doing, how admirably the plant is accomplishing its task and similar "human interest" propaganda, will do wonders in winning the recognition that the power plant and its crew usually deserve.

Looking Ahead

IN THE story of Sir Charles Parsons, appearing in this issue, mention is made of the great inventor's interest in the idea of boring a very deep shaft in the crust of the earth to tap the great store of heat which undoubtedly exists far below the surface. The idea is a fascinating one and seemingly impractical enough to satisfy the most dreamy theorist. Yet even today volcanic heat is being used in Italy to produce steam, although this installation is probably more in the nature of an experiment than a practical commercial enterprise. However, the thing has been done, and it may be argued that to use the earth's heat by making a deeper bore in some locality where the molten interior is farther from the surface than in the volcanic region of Italy, is simply a step—a long step to be sure, but involving magnitude rather than principle.

It is well known that many inventions that are now familiar to us and are taken as a matter of course were ridiculed upon their inception. One can imagine Ben Franklin's wife saying to him, after the famous kite experiment; "Ben, in some respects you are a very wise man, but sometimes your childishness exasperates me." And as for Watt, it is probably that, as he sat before the fire and watched the steam hissing from the kettle spout, his father told him to wake up and get busy on the woodpile. So let us not be too intolerant of ideas that seem chimerical, lest future generations laugh at us as we laugh at the critics of Franklin and Watt.

Probably no one alive today will live to see the heat of the earth's interior taking the place of coal and oil in the production of power to any practical extent, but it is possible that our descendants may see such a development. Perhaps, too, when the world's supply of fuel nears exhaustion, they will see the increasing use of windmills and the development of tidal and wave power. At present, however, and for many years to come, the excessive investment required to produce power by any

of these methods rules them out as commercially impractical.

What the future will bring, Sir Charles himself cannot say, nor can anyone. But in the light of history it seems as though nothing can be so inconceivable and far-fetched to one generation that it cannot be brought down by the next to the humdrum reality of every-day life.

The Unemployment Conference

ALL eyes have been turned toward Washington during the last week, and nation-wide and even international attention has been accorded the conference that was called there on September 26 to consider means of handling the most pressing problem of the time—unemployment. The idle thousands who are finding nights in the parks increasingly chilly are not the only ones who have been waiting with hopeful expectancy for news from the conference; the faults in our economic system that have brought about their present condition, as well as the complications arising from their plight, are of serious moment to us all and affect our success as individuals and as a nation. Even foreign nations, according to President Harding, are paying keen attention to our method of treating the unemployment problem, because they have the same problem to meet in varying degrees of complexity and seriousness.

England, in particular, has been most unfortunate. Probably the disastrous results of that nation's charitable efforts to relieve distress among its unemployed workers through direct money payment were at the bottom of the strongly expressed feelings at the Washington conference that no remedy savoring of charity should be considered. "I would have little enthusiasm for any proposed relief which seeks either palliation or tonic from the public treasury," said President Harding in his address at the opening of the conference, and Mr. Hoover touched the same point in his address when he said, "We have so far escaped this most vicious of solutions and I am hopeful, and I believe you will be, that it is within the intelligence and initiative of our people that we may find remedies against hardship and bitterness that do not—except in exceptional cases—come within the range of charity."

It is a hopeful sign that such a sentiment pervaded the conference, for it is a sound one, and its adoption means that we shall not have to face in this country the chaos resulting inevitably from a practice that puts a premium upon idleness.

Another noticeable feature of the preliminary work of the conference, this also being of a negative character, was Secretary Hoover's emphasis of the need for accomplishing the desired results without having recourse to legislation. "The Administration has felt that a large degree of solution could be expected through the mobilization of the fine co-operative action of our manufacturers and employers, of our public bodies and local authorities, and that if a solution could be found in these directions we would have accomplished even more than the cure of our unemployed, that we will have again demonstrated that independence and ability of action among our own people that saves our Government from that ultimate paternalism that will undermine our whole political system." Not only that, but legislation takes time, and this is a case where immediate relief is a prime necessity.

Briefly, the conference met to determine the extent of the trouble, to decide upon the temporary relief to be given, and to make constructive recommendations toward a permanent solution of the problem.

Defective Electrical Installations

WHEN a boiler explodes or a flywheel fails, there is generally a catastrophe of serious proportions. Not only is there property damage, but in many cases a loss of human life results. Whatever question may be raised as to what actually caused the boiler or flywheel to fail, there can be no doubt as to what caused the damage. The equipment wreckage remains to bear witness to what happened. With an electric circuit conditions are entirely different. If, due to a defective electrical connection or insulation or other conditions in a circuit, a fire is started, the evidence is burned up in most cases. This fact acts in two ways; it prevents, as in all cases where evidence is lacking, the proving or refuting of the charge.

No one will deny that faulty electrical installations have caused some disastrous fires, but this is no reason for, when the cause of a fire cannot be accounted for any other way, attributing it to faulty electrical insulation. This is not an uncommon practice, especially among those not familiar with electrical principles, and it has resulted in the presence of electrical circuits being blamed for conflagration due to other causes. The electrical installation being burned up, nothing remains to prove whether defective insulation was the cause, but electricity gets another black eye in the public mind.

Practically everything that is beneficial to the human race is capable of producing disastrous results if not rightly applied. Boilers that are not properly taken care of and protected blow up; when the governor fails to function either through neglect or otherwise, the engine or turbine will overspeed and be wrecked; an automobile in the hands of a reckless driver is a menace to life and property; electric circuits and equipment improperly installed and maintained are also a hazard. However, the fault is not in every case in the device or medium, but in the method of application. If rightly designed, installed, maintained and operated, they all contribute to making human existence more enjoyable, but when neglected the results are frequently calamitous.

Knowing that faulty electrical installations can cause serious destruction only emphasizes the necessity of proper installation and maintenance. The current-carrying parts of an electric circuit are in the main concealed in conduit or in the coils on the equipment, therefore they cannot be inspected as readly as many mechanical equipments can. However, the insulation resistance of an electric system is easily determined. If this test is made three or four times a year, a careful check can be kept on the condition of the installation, and any weakness developing in the insulation detected. This, along with the proper care of the exposed parts, will go a long way toward the prevention of dangerous conditions. It is in general realized that the mechanical end of the power equipment must be carefully looked after or serious happenings may occur. Why not also give the electrical part equal consideration even if it has not to its credit the serious disasters of steam machinery?

CORRESPONDENCE

Recorder of Both Combustible Gases and CO_2

I have read with considerable interest Roland Moeller's article, "A Recorder of Both Combustible Gases and CO_2," appearing in the July 12 issue of *Power*. This article is intended primarily to show the necessity of having a continuous analysis and record of both CO_2 and combustible gases escaping up the stack, and the argument to prove this claim is based on the results of certain actual boiler tests. If the boiler on which the indicated observations were taken was a true representative of boilers as a class, the deductions made would be of considerable value. However, the results as given in Table I would indicate that the boiler in question was not of a class that should be used as a test apparatus for obtaining such important information. The last set of figures given in Table I, representing the results obtained when the boiler was operating under the best possible conditions, the unnecessary flue loss being zero, indicate only 6.66 lb. of steam produced per 10,000 B.t.u. in the fuel. Although it is not stated what sort of steam is meant, the value of such steam will not be far from 1,000 B.t.u. per pound. On this assumption the 6.66 lb. of steam per 10,000 B.t.u. would show an efficiency of 66.6 per cent. Any boiler, when operating under the best possible conditions and showing an efficiency of only 66.6 per cent cannot be much of a boiler.

Considering the first set of results obtained, with a leaky boiler setting, dirty fire, poor firing and bad draft regulation, we find 5.44 lb. of steam produced per 10,000 B.t.u. and an unnecessary flue loss of 22.5 per cent. On the same assumption of 1,000 B.t.u. per pound of steam, these results would show an efficiency of 54.4 per cent, only 12.2 per cent lower in efficiency than when the boiler was operating with the best possible conditions existing, showing at the same time an unnecessary flue loss of 22½ per cent. It is difficult to visualize a case where an individual boiler loss, such as the stack loss, should increase 22½ per cent and yet reduce the over-all efficiency only 12.2 per cent unless in decreasing the stack loss, other losses, principally the ashpit loss, increase. If the necessary stack loss is of the same magnitude in both cases, which it is only fair to assume, then while the stack loss decreased 22½ per cent the other losses increased 10.3 per cent because the efficiency is equal to 100 minus the sum of individual losses.

It would be well, therefore, before assigning too much importance to the necessity for a continuous CO_2 and combustible gas record, to have a little more information regarding the tests which are used as a basis for the statements made in this article. It is quite simple to draw any conclusions we may wish, if we consider only one part of the results of any test. To be of any value the record of any test must show what all the conditions were in order that the results may be intelligently analyzed. In this connection it would be interesting to know whether the three sets of results as given were obtained when the boiler was operating at the same rating in all cases, what this rating happened to be, what the type and size of boiler were, what grade of coal was used and the type of stoker or furnace. All these factors have an important bearing on the value of the results, as the basis for any argument.

The seriousness of the loss due to combustible gases passing up the stack is not to be discounted, but how serious this loss is depends chiefly on the type of furnace, and with any given boiler and furnace the "critical" CO_2 percentage can readily be determined by means of an Orsat apparatus.

While it is frequently found that a considerable amount of CO is in evidence notwithstanding considerable excess air, such conditions will most often be found with old-style low-set boilers having insufficient combustion space or boilers with badly leaking settings. These conditions can both be determined and overcome without the use of a recording CO meter. The maximum CO_2 for economical operation is today often governed by the furnace temperature. This applies, of course, more particularly to modern boilers having proper combustion space. If the CO_2 percentage is kept within reasonable limits, the loss due to combustible gases will be negligible. If 12 to 13 per cent of CO_2 is maintained with the ordinary coal-burning furnaces, little more need be expected toward better efficiency as far as combustion is concerned. The CO_2 records reproduced in this article bear out this statement. Fig. 4 shows a CO_2 averaging approximately 15 per cent, which is considerably higher than is ordinarily considered good practice, and in this case the corresponding record shown in Fig. 3 of Mr. Moeller's article indicates a considerable CO content.

In the last case, as illustrated in Fig. 6, the CO_2 average is about 12 or 13 per cent, and in this case very little combustible gas is shown on the corresponding chart, Fig. 5. The biggest loss is practically always occasioned by excess air, and the spotting of this loss can satisfactorily be taken care of by means of a CO_2 recorder alone. The function of the CO_2 recorder is not to enable a fireman to maintain the highest possible

CO_2, but to guard against operating at 8 or 9 per cent. On special tests it is sometimes desired to squeeze the last possible heat unit of the coal into the steam, but this is extremely poor policy when operating a boiler under practical every-day conditions. It is frequently found that the CO_2 must be held down to 12 or 13 per cent in order that the furnace linings and grates will not be damaged, due to excessively high temperatures, and the CO_2 is then accordingly kept within certain limits—not to guard against unburned gas loss, but to reduce the maintenance cost of the furnace.

Referring to the curves showing losses due to excess air, CO and combustible gases, as given in Fig. 7, it is hardly possible that these would be reliable except in a few particular cases, and they are therefore of little value in general.

W. C. LANGE.

Chicago, Ill.

Providing for Expansion in Smoke Breechings

Although I have at various times read articles dealing with the subject of smoke breechings, I have read nothing relating to taking care of the expansion or contraction of this important part of the boiler-room equipment. Although the purpose of the smoke breeching is to convey the hot gases from the boiler furnace to the stack, thought should be given the subject of expansion, as the heat in the flue gases causes the breeching to expand when the boilers are put into service, thereby causing the breeching to buckle, which may throw strains on the boiler setting and cause leaks.

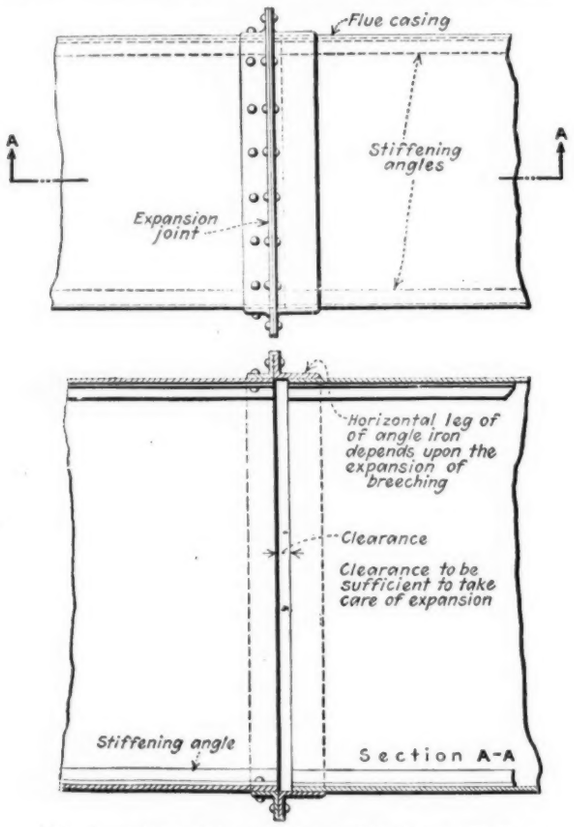


FIG. 1. EXTERIOR AND SECTIONAL VIEWS OF BREECHING EXPANSION JOINT

To get an idea of the importance of this matter, let us determine what the expansion of a wrought-iron smoke breeching will be, assuming the length of the breeching to be 40 ft. and the temperature of the flue gases 600 deg. F. The coefficient of expansion for wrought iron is 0.0000067. $40 \times 12 = 480$. $0.0000067 \times 600 = 0.00402$. $0.00402 \times 480 = 1.9296$ in. expansion or $1\frac{15}{16}$ in. This means that a smoke breeching operated under the foregoing conditions will expand

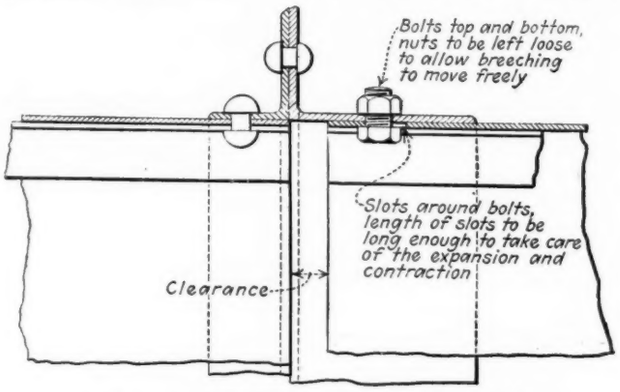

Bolts top and bottom, nuts to be left loose to allow breeching to move freely
Slots around bolts, length of slots to be long enough to take care of the expansion and contraction
Clearance

FIG. 2. EXPANSION JOINT USING BOLTS

$1\frac{15}{16}$ in., and that some provision should be made to take care of this expansion.

The accompanying illustrations show two proposed methods of taking care of expansion, after having determined what the expansion will be. The design of expansion joint can be used on either round or square breechings, and the preferable location is midway between the total length, or, as in the case outlined in the foregoing, the total length of the breeching being 40 ft., the joint should be located approximately 20 ft. from the end of the breeching, or as near this distance as the design will permit. This will allow the breeching to expand equally in both horizontal directions.

The expansion joint can be made as shown by Fig. 1 without the use of bolts, or, if desired, it can be made as shown by Fig. 2, using bolts, in which case the angle iron both in the top and the under side of the breeching are drilled for the bolts; but the edge of the flue casing is provided with slots; the length of which should be of the same length as the clearance required for the expansion. The nuts on the bolts should be left loose to allow free movement of the breeching.

Brooklyn, N. Y. H. BLOMGREN.

Taking Up Lost Motion

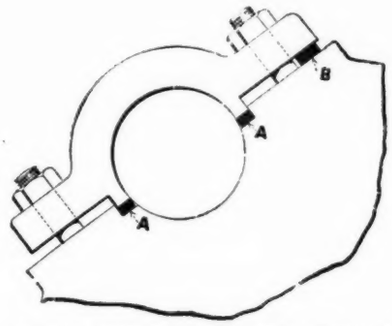
A method that I have used for some time in locating lost motion in an engine is to set the crank anywhere that is convenient, and, with the hook rod lifted, put a finger on the crankpin so that it will touch both pin and brass at the same time. Then I have an assistant operate the starting bar and give the engine a little steam, so as to rock it back and forth. If there is any lost motion it is easily felt. The same operation is repeated for the wristpin.

For the crosshead the crank is placed on, or a little past, the half stroke, the finger is put on the crosshead and guide at the same time and the engine is rocked as stated. For the pillow block, place the engine on a dead center and put a finger on the crankshaft so that it will also touch the pillow block, and then give the engine a good head of steam and reverse as before.

Boston, Mass. P. B. SUMNER.

Preventing Main-Bearing Studs from Breaking

The studs in the main bearing (designed as shown in the sketch) of a tandem steam-driven air compressor, broke frequently. Pulling the cap down tight on the



METAL SHIM PREVENTED TROUBLE

regular shims *A* had no appreciable effect, but when a solid metal shim *B* was inserted, the trouble was remedied.

R. McLAREN.

Toronto, Canada.

Cutouts for Motor Protection

Referring to my article on "Cutouts for Motor Protection," on page 260, Aug. 16 issue, an error of a rather serious nature appears in Fig. 1 which has not been reproduced as submitted by me. This illustration shows a pair of "motor" fuses in series with a pair of "line" fuses. It seems obvious that, in a straight series circuit without branch or tap, no added protection results from the use of two fuses in series. If the fuses are all of the same rating, nothing is gained by adding the second pair; and if they are not, the smaller pair determines the protection.

The figure as shown would apply only to the special case of a branch line designed ultimately to supply several motors, or one motor of larger capacity than the one actually installed, provided that motor be of the squirrel-cage induction type, larger than 2 hp. continuous rating, and used for constant-load service. In most cases the line would be designed with sufficient capacity to supply the motor, and the line fuses would be figured to give the necessary protection to both the line and the motor.

New York City. EDGAR P. SLACK.

[The foregoing criticism is well founded, and the figure as shown has no place in a discussion of the requirements of the National Electrical Code, for under no conditions does the Code require the use of two sets of fuses in series. The error is unfortunate, therefore, in that it might be construed as a Code requirement. Although it is inaccurate in this respect, the figure does picture a condition that occurs frequently in practice. When the wiring of a manufacturing plant is laid out, it is practically impossible to know exactly the amount of power that will be demanded of the different circuits, and these must be installed with liberal capacity, to provide not only for probable inaccuracies in the power estimates, but for future development that may require the installation of larger machines. Furthermore, especially in the case of branch lines of considerable length, it is often inconvenient to use the line fuses for the protection of the motor, particularly on machines subject to heavy duty and frequent fuse renewals. Under these conditions the line fuses are made of the right capacity to protect the line—that is, too large for the motor—and motor fuses of smaller capacity are installed directly under the motor switch for the protection of the motor. This is the condition pictured in Fig. 1.—Editor.]

What Is the Matter With the Steam Table?

I have just observed readings in the saturated-steam table that are not clear to me. It will be noted that the total heat of steam from a temperature of 32 deg. F. increases until a temperature of 480 deg. is reached. From this temperature the total heat of the steam decreases until a temperature of 600 deg. F. is reached, and the table gives no total heat of the steam beyond this figure.

At a temperature of 470 deg. F. the total heat of steam is given in the table as 1,210, and this is the same at a temperature of 520 deg. F. Why does not the total heat of steam keep on increasing at temperatures above 510, and why should there be the same total heat of steam at temperatures from 480 to 510 deg. F.? Perhaps someone will explain this apparent discrepancy.

J. W. DOUGLASS.

Cleveland, Ohio.

Opening and Closing Blowoff Valves

In blowing down a boiler the slowest-opening valve should be operated last. The reason is apparent, because it is always safest to start letting the water out slowly. To open the valve quickly when under pressure will cause a dangerous strain in the region of the blowoff, and rupture of the pipe many result. Water has little compressibility and becomes dangerous at a high velocity unless proper care is taken in handling it. A cock is a quick-opening appliance and is likely to stick. A careless fireman will hit the handle a hard blow, causing the cock to open wide instantly. If this is the last valve to be opened, the blowoff line will receive a bad water hammering and some of the fittings may break.

In placing the valve and the cock on the line, the valve should be nearest the boiler. Because the cock is so liable to cause a water hammer, it is closed last. To put it between the valve and the boiler would mean that it would have to be turned in the scale lodged around it when the valve is closed. The cutting effect of scale is well known, and the cock would soon become scoured and leaky and its usefulness destroyed. If the cock is outside of the valve, it is free and clear of dirt and scale when operated. The valve, being of slow movement, allows the water to lose its high velocity and the scale to sink to the bottom of the pipe and come to rest, and during the final shutting only very small particles can pass through and these do not interfere much with tight closing. If the cock gives trouble by sticking, it can be removed if on the outside, but if on the inside a shutdown is necessary for repairs.

The District Police Steam Boiler Rules of Massachusetts allow two valves or a valve and a cock, but never two cocks, on the blowoff line. It is intended to protect the boiler by having the valve opened last and closed first.

Rockland, Mass. BURTON W. WHEELER.

Mr. Ford and His Muscle Shoals Proposition

Gifford Pinchot's letter in the Sept. 13 issue of *Power* is convincing, and I feel that more should be obtained for the Muscle Shoals plant if possible. However, rather than lose the whole plant, or rather than have it lie idle, I am in favor of turning it over to Mr. Ford unless a better offer is obtained from somebody else, or unless the Government decides that it can be governmentally operated at greater profit, or to better advantage—which very few people will believe these days. I understood that the Muscle Shoals plant would be a "total loss" up until the time Mr. Ford made his offer, and most of us thought that he had done something remarkable.

As I view it, simply because it is Mr. Ford who is making the offer we have no right to ask more of him than we do of others. Not long ago the newspapers told about some wooden ships that cost the Government $600,000 each. It is understood that they were sold for $2,500 each to a large organization that could probably have paid considerably more. At that rate, using Mr. Pinchot's statement that both Nitrate plants cost the Government 85 million dollars, Mr. Ford could buy both plants for about $330,000. He has offered five million.

Most people understand that during the war Mr. Ford did not indulge in profiteering, which is more than can be said for the average steamship owner. The Government has demonstrated that it does not know how to operate railroads. Mr. Ford, apparently, does know how to operate railroads. He seems to be straightforward and honest in everything he undertakes and, above all, he is a business man.

Mr. Ford certainly has a right to make any sort of offer he wishes. We, the people of the United States, have the right to accept or reject his offer. What we will do should depend largely upon other offers received.

Newark, N. J. W. F. SCHAPHORST.

Testing Small Air Compressors

After reading Mr. Garvin's method of testing an air compressor in the Sept. 6 issue of *Power*, page 388, I wish to suggest what I believe to be a better method and one that will apply to almost any type of compressor whether single- or double-acting or single- or multi-stage. All that is needed is a supply of air at any convenient pressure with a valve in the line between the supply and the compressor.

Assume first a single-acting single-stage compressor. To test the discharge valve, remove the suction valve and by opening the valve in the supply line allow the air pressure to come on the discharge valve. If there be any leak, the air will blow out through the suction-valve opening. Then replace the suction valve and remove the discharge valve, but replace the bonnet. Pressure is again applied, and it is easily ascertained if there is a leak either past the suction valve or past the piston rings.

If, for example, the first-stage valves of a three-stage compressor are to be tested, remove the valves of the second and third stages, replace the bonnets and proceed as described in the foregoing. It is also possible to test the intercoolers, aftercooler and any joints by this method. CHARLES H. BUSHNELL.

San Francisco, Cal.

Pull-in Torque of Synchronous Motors on Air Compressors

The results of my investigation concerning starting and pull-in torques required for synchronous motors driving air compressors may be of interest. Motors on simple compressors without flywheels require 15 to 20 per cent of full-load torque to pull into synchronism unloaded.

If they are equipped with flywheels the torque will be greater, up to 20 to 25 per cent full-load value. Motors on duplex compressors without flywheels require 20 to 25 per cent full-load torque to pull into step unloaded. The presence of a flywheel increases this requirement to 30 to 35 per cent. The use of a flywheel increases the requirement due to increased friction, but more particularly due to inertia.

In view of these facts I believe the requirement of 50 per cent pull-in torque, as specified in my article, "Motors for Driving Air Compressors," May 17, 1921, issue, and taken exception to by Quentin Graham in the June 28 number, to be reasonable in connection with duplex compressors with flywheels. With other types of compressors motors having somewhat lower torques might be permitted. Low-speed synchronous motors can be obtained developing 40 per cent full-load pull-in torque at 250 per cent full-load kilovolt-amperes. If an oversize machine is used in order to have marginal rating for power-factor correction, as is usually the case, 50 per cent torque can be obtained without undue difficulty.

The foregoing statement represents data obtained from several reliable sources.

Chicago, Ill. GORDON FOX, Elec. Eng.,
Freyn, Brassert & Co.

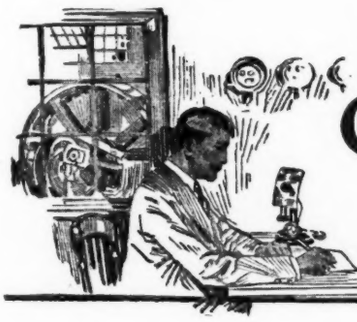
Scientific Boiler Feeding for Variable Loads

In the Sept. 6 issue of *Power*, page 388, A. J. Dixon accurately describes the results obtained in the effort to mechanically control the flow of boiler-feed water to the boilers with equipment of the intermittent or spasmodic type. The severe load conditions under which the boilers operate make the results of this method of feeding more apparent.

The hand regulation mentioned, while taking care of the load requirements so far as priming is concerned, decreases rather than increases the boiler efficiency, as the water input is not continuous. To obtain the most desirable results and maximum efficiency, the feed input for the conditions described should be in inverse ratio to the steam output or load, with a continuous feed or constant flow assured at all times.

A system of mechanical feed-water regulation of continuous flow, variable-level type, would successfully meet the condition described by Mr. Dixon, and installations of this style of boiler feeding are daily giving satisfactory results in shops where several steam hammers frequently get in step and the pull on the boilers is severe at times, the variation in load requirements being excessive. The advantages obtained from a system of this character of feeding is comprehensively described in the article under the head of "Influence of Irregularities of Boiler Feeding," page 390 of the same issue. C. E. WOLFF, JR.

Erie, Pa.



INQUIRIES OF GENERAL INTEREST

Change of Piston Clearance from Keying up Connecting Rod—How is the piston clearance of an engine affected by keying up a solid-end connecting rod that has the keys between the pins? R. W.

When the keys are between the crankpin and the crosshead pin, keying up has the effect of lengthening the distance between the pins, thereby causing the piston in its stroke to be carried nearer the head end of the cylinder. Hence there will be reduction of piston clearance in the head end and increase of the clearance in the crank end of the cylinder.

Removing Rusted Tap Bolts and Nuts—How can tap bolts and nuts that have become rusted be removed from a waterwheel case? C. P.

To loosen tight or rusted tap bolts or setscrews, strike the heads of the screws a number of sharp blows with a medium sized hand hammer, and to loosen nuts strike the end of the bolts covered by a short tool, countersunk to prevent the screw threads from becoming mashed. If the tap bolts and nuts cannot be loosened in that manner, then after the parts have become thoroughly dried of water, repeat the process at intervals with free application of kerosene.

Operation of Leblanc Air Pump—What is the principle of operation of the Leblanc air pump? A. H. M.

The Leblanc air pump consists primarily of a reverse Pelton waterwheel in conjunction with an ejector or funnel-shaped nozzle, that is connected with a space containing non-condensable vapor and air to be withdrawn by the air pump. Sealed water is introduced into a chamber central with the wheel, from which it passes to a port at the periphery. The wheel is rotated at a high velocity and the water, being caught up by the blades, is carried through nearly a complete circumference and then "hurled" tangentially into the discharge cone in the form of thin sheets having high velocity. These sheets of water meet at the contracted part of the discharge cone and thus form a series of water pistons, each of which entraps a pocket of "air" and forces it out against the atmospheric pressure. In passing through the air pump, the sealing water receives practically no increase of temperature, and the same water can be used over and over again.

Safe Voltages and Electric Shock—What is the highest voltage that a human being can safely "take" through his body? F. A. N.

It is a fallacy to say that the human body can stand a certain voltage, for it is not the voltage but the actual current flowing through the body under that voltage that does the harm. If the body is carrying 0.1 ampere, it makes no difference whether this is produced by 100 or 1,000 volts, the effect on the organs will be the same. Thus a low voltage with an exceptionally good contact may cause the same current to flow through the body as a high voltage with a poor contact. Many people have been killed on 110-volt circuits, because they happened to be standing in water or on wet ground, or because their skin was damp where it came in contact with the live wire. The effect of current on the human body is uncertain at the best. Some people are more sensitive than others, and one may stand a certain current with impunity while another may be killed by a much smaller current. Much depends on whether or not the current flows through a vital organ. Besides this the resistance of the human body varies widely, depending on the thickness of the skin and a number of factors about which little is known. It seems pretty well established that this resistance is largely one of contact, and this depends on the moisture of the surfaces of contact, both with the conductor and the ground. The important lesson to be gathered from the foregoing is that no live circuit should be considered safe, even at 110 volts. A grounded circuit is particularly dangerous, as the current usually flows through the whole of the body, including the heart, to reach the ground.

Purging Ammonia Condenser—Is it possible to remove all foreign gases by purging an ammonia condenser? A. L. T.

It is not, for even though the contents of the condenser are reduced to a low temperature some ammonia still will be in a vaporous condition. This is for the reason that the pressure exerted by a mixture of gases is made up of the sum of the pressures exerted by each gas. Even though the condenser pressure be kept high, say 175 lb. gage (190 lb. absolute) and the temperature reduced to 60 deg., part of this pressure will be due to the ammonia vapor. At 60 deg. F. the saturated or boiling temperature of ammonia is 92 lb. gage (107 lb. absolute). Then of the gaseous contents in the condenser $\frac{107}{190}$ of the volume is made up of ammonia and the remainder $\frac{83}{190}$ is foreign gas. The best method is to purge into a tank of water, which will absorb the ammonia to be later purified and recovered.

Pumps Using Steam Expansively—How can steam be used expansively for operation of a pump? H. H. C.

For operation of piston pumps, the power must be sufficient to overcome the discharge pressure at every point of the stroke, and hence, to use the steam expansively, in direct-acting pumps there must be pistons in high and low pressure cylinders, on the same or connected piston rods, with high- and low-pressure units acting simultaneously for movement of the water piston in the same direction. Another method of using the steam expansively is to employ a compound engine with a crank and a flywheel for storing energy during that part of the stroke when the steam pressure is in excess of the pump resistance, and for restoring the surplus energy to that portion of the stroke where the expansion force of the steam would not be sufficient for overcoming the pump resistance. Other methods that have been used for effecting temporary storage and restoration of energy are by means of the compressing and re-expanding of air, raising and falling of weights, and distortion and recovery of springs.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Iron and Steel Electrical Engineers Hold Convention in Chicago

DURING the week of Sept. 19 the Association of Iron and Steel Electrical Engineers held its fifteenth annual convention at Hotel La Salle, Chicago, with President Jefferies and J. F. Kelly, secretary, officiating. The convention was well attended, as indicated by a registration approximating 400, and with an unusual number of excellent papers, arranged two per session to give plenty of time for discussion, was a decided success. The educational features of the convention were enchanced by exhibits of representative manufacturers of electrical steel-mill apparatus and by inspection trips to plants of interest in the city. In the way of entertainment there was informal dancing on Monday and Thursday evenings, a picnic Tuesday afternoon tendered by the independent steel companies of the Chicago district, and the annual banquet Friday evening.

Contrary to usual procedure in other associations, the first order of business was the election of officers for the ensuing year, which resulted in the following selections announced the night of the banquet: President, W. S. Hall, electrical engineer, Illinois Steel Co.; first vice-president, R. B. Gerhardt, electrical engineer, Bethlehem Steel Co.; second vice president, L. F. Galbraith, electrical engineer, West Penn Steel Co.; treasurer, James Farrington, electrical superintendent, La Belle Iron Works; secretary, J. F. Kelly, Pittsburgh; directors—R. R. Sheppard, electrical superintendent, Steel and Tube Co. of America; I. N. Tull, electrical engineer, McKinney Steel Co.; F. H. Woodhull, electrical superintendent, Lukens Steel Co.; W. H. Gilbert, electrical superintendent, Tennessee Coal, Iron & R.R. Co.

Doings of the Monday Afternoon Session

At the session Monday afternoon the following papers were presented: "Some Recent Developments in Induction-Motor Starting," by M. C. Spencer, designing engineer of the Crocker-Wheeler Co., and "The Electrical Engineer in the Steel Plant and Out," by F. B. Crosby, Electrical engineer of the Morgan Construction Co. Mr. Spencer limited his remarks to improved methods of starting squirrel-cage induction motors by means of auto-transformers or compensators. In the usual method a heavy rush of current is drawn from the line when the motor is first connected through auto-transformers, and a second heavy current rush when the transformers are disconnected and the motor connected directly to the line. To reduce this second rush of current a new drum-type starter has been developed which keeps the power on the motor during the whole of the starting period. Details of its operation were given and attention was called to a signaling device which further reduced the possibility of a second heavy line disturbance by indicating to the operator when the current is low enough to permit throwing over from the starting to the running position. The same device also indicates a 20 per cent overload, so that when used in connection with overload relays which trip out at 30 per cent overload, it serves to give warning of an impending shutdown. The author also described a new protective device designed to replace the usual mechanical dashpot in giving the delayed action desired before the relay trips to shut down the motor as a guard against overheating caused by overloads. The new device depends for its delay action on the heating of a short strip of special sheet iron connected in series with the circuit to be protected and in parallel with the relay which trips the switch. A new type of starter in which the transformers are located outside of and attached to the bottom of the case in the open air so that they will operate at a lower temperature, was illustrated, and a diagram given of the panel arrangement for small electrical parts, which is also secured to the case.

At the session Tuesday morning, R. B. Gerhardt, electrical superintendent of the Bethlehem Steel Co. at Sparrow's Point, predicted the electrification of the steel-plant railroad. In his paper on the subject the author compared the steam and electric locomotive to the advantage of the latter from the standpoints of fuel, repairs, operating labor, locomotive depreciation, station service and safety. Operating costs presented showed large savings for electric operation over steam.

In a paper on "Anti-Friction Bearings in the Steel Mill," A. M. MacCutcheon considered the advantages and disadvantages of replacing the older oil-ring type of bearing. The various types of anti-friction bearings were considered in a general way with comments on manufacture, selection, mounting, care of bearings and results from experience that had been gained by the use of ball bearings in equipment of various kinds.

Fuel Economy Day

Wednesday was "Fuel Economy Day" conducted under the auspices of the new section on combustion engineering, with F. E. Leahy, chairman of section, in the chair. The following four papers were on the program: "Fuel Requirements of Steel Mills," by F. E. Leahy; "The Control of Boiler Operation," by W. N. Flanagan; "General Use of Oxygen in the Steel Mill Industry," by E. A. W. Jefferies; "Waste Heat Utilization for Steam Generation," by G. R. McDermott. The paper first named dealt with the various forms of fuel—solid, liquid and gaseous—used in the mills, touched upon the economic considerations such as transportation, storage and distribution, and outlined some of the peculiar requirements and reasons why it is desirable to use certain kinds of fuel in the various steel-mill operations.

In the discussion on the paper attention was called to the desirability of taking an occasional heat balance, as it would assist in planning improvements, in properly proportioning the blast-furnace gases between the different services and in getting the most out of it. Reference was made to the increasing use of coke braize even in the smaller plants, in the equipment installed, at efficiencies of 60 to 65 per cent. In a specially designed waste-heat boiler 27 tubes wide and 24 tubes high, efficiencies as high as 80 per cent, as compared to the usual 70 per cent, had been obtained. Coke-oven gas had been burned with good results in open-hearth furnaces, but greater capacities were obtainable with tar. Proper boiler settings for different kinds of fuel was a subject given brief consideration.

In his paper Mr. Flanagan showed the advantages of automatic boiler control over hand manipulation. It was his idea that the station should advance as a unit to meet the load. An abstract of this paper will appear in an early issue.

In the discussion it was pointed out that plant efficiency was an aggregation of individual boiler efficiencies, so that to get good boiler-room results, it was necessary to keep each boiler operating near the point of maximum efficiency. In burning coal in the boiler furnace, time was not a factor of combustion efficiency, so that with a flexible stoker that could be adjusted quickly to meet varying demands, such as the forced-draft chain grate, practically the same efficiency could be maintained at high overloads as at rating. This eliminated the necessity of banking boilers with a drop in the load and small irregularities had no effect on the efficiency. The same speaker believed in individual fans and automatic regulation to maintain uniform efficiency. Attention was called to the possibilities with powdered coal, with which efficiencies approximating 84 per cent could be maintained continuously, and to the difficulty of arranging automatic control in the same furnace for the number of fuels available in the steel mill. The importance of instruments in maintaining efficiency, and of flow meters in particular, was emphasized. Flow of steam rather than pressure was preferred for regulator control and some attention was given to the possibility of controlling the flow

of feed water to help in load variations, more water being fed temporarily when the load dropped and less as it became heavier.

In the paper on "The Influence of Cheap Oxygen on Economy of Fuel and Time," the author, E. A. W. Jefferies, announced that the problem of cheap oxygen had been solved. When made at the rate of 4,000 cu.ft. per minute, it could be produced for 8c. per 1,000 cu.ft., as compared to the present rate of $10 to $15 per 1,000 cu.ft. when bought in the usual storage cylinder. In general the process consists of liquefying air by compression and expansion and then distilling off the volatile nitrogen just as now done in the Linde and other processes, but instead of consuming large amounts of power to drive compressors and then throwing practically all the work away by free expansion into the still, the new method is based on the idea of carrying on the distillation at the pressure to which the air is originally compressed. In this way the nitrogen, constituting about 80 per cent of the whole volume of air, leaves the still under the original pressure. It can then be heated to increase its volume and power capacity and used in a piston engine to drive the compressor. Thus no external power is required for operation, but instead a comparatively small amount of fuel.

In the steel industry and in other fields the availability of cheap oxygen constituted prospects of the greatest conceivable importance. The author intimated that fuel gas of 400 B.t.u. could be produced for 8c. per 1,000 cu.ft. The gas contained about 60 per cent carbon monoxide whose flame temperature is higher than that of any other gas in general use, making it more useful than either coke-oven or natural gas. Uses of the oxygen in the open-hearth furnace, in the blast furnace and many miscellaneous uses such as cutting up metal, welding and for stimulating combustion were briefly touched upon by the author. The discussion centered upon combustion temperatures that would prevail when enriching with oxygen and the impossibility of present refractories withstanding such temperatures. In the power plant it would necessitate the redesign of boilers and furnaces.

Waste-Heat Utilization

In a comprehensive and valuable paper on "Waste-Heat Utilization for Steam Generation," G. R. McDermott reviewed what had been accomplished in the utilization of waste gases for steam generation and pointed out sources of waste heat that may be available, referring in particular to open-hearth furnaces, soaking pits, reheating furnaces, malleable melting furnaces, forge furnaces and gas engines using blast-furnace gas. To utilize the source of waste heat last named, the author had designed a high-gas-velocity, fire-tube, single-pass, waste-heat boiler to take the exhaust at a temperature of 850 deg. F. from 3,300-kw. gas-engine units. Based on an average load of 3,000-kw., it was estimated that the boiler would generate 2.6 lb., net, of steam per kilowatt-hour at the switchboard. Heat and absorption phenomena in direct-fired and waste-heat boilers were compared and the relative merits of water-tube and fire-tube boilers as absorbers of waste heat discussed. The author favored the latter type, referring in particular to the Bacon waste-heat boiler, due to the smaller cubic space occupied for equal capacity and the greater heat absorption due to the smaller tubes employed and the high velocity of the gases, which incidentally keeps the heating surface free of dust accumulation.

In the discussion the application of certain empirical formulas for obtaining the heat transfer through the whole range of tube sizes and gas velocities was questioned and more information requested on relative costs of the two types of boiler and operating experience at the higher gas velocities. Heat transfer by convection was the big problem, as over 90 per cent of the heat was absorbed in this way. Other problems requiring attention were the rating of waste-heat boilers and with the prevailing variation in settings and operating conditions, the taking of data that would be comparable. The time was ripe to join hands with the committee of the American Society of Mechanical Engineers who were now revising the Code and get up a code on testing waste-heat boilers.

Reports of Committees

Owing to inactivity in the steel industry during the last year, much of the work outlined by the Electric-Furnace Committee, involving as it did continuity of operation, could not be completed. The report, presented on Thursday morning, was limited to comments on heat losses from electric furnaces, electrode specifications and a comprehensive dissertation on the merits of dual voltages.

Because of the depression the Electrical-Development Committee had little to report on new developments in the various branches of the field. More activity had been shown in control equipment than in any other single line. It was now possible to obtain a steel-mill controller with contacts and arc chutes lasting from 15 to 20 times longer than former designs.

As the fruit of the year's work the Educational Committee presented a "Crane-Operators' Manual," with detailed instructions on the duties of crane operators relative to operating orders, entering crane, inspecting, operating, maintaining and leaving crane and reports. The manual also included elementary theory on electrical operation with operating instructions on knife, magnetic and limit switches, fuses and overload relays.

On Friday the last session was devoted to the report of the Standardization Committee, including the presentation of electric overhead-travelling-crane specifications and reports of sub-committees on motors and illumination. The specifications referred to heavy-duty steel-mill cranes and were more or less general to give the steel mills more leeway when purchasing cranes while still giving protection and by insuring that the different builders conform with standard specifications, putting bids on a competitive basis. Of those present at the meeting some thought that the specifications had been liberalized too much and in some respects might be misleading to the user of small cranes outside the steel industry.

The sub-committee on motors reported that the general specifications on alternating-current motors for main-roll drives had been revised and would not require further change until new developments had taken place in the art.

ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS AS GUESTS OF CHICAGO DISTRICT INDEPENDENT STEEL COMPANIES

For direct-current mill-type auxiliary motors, uniform fundamental dimensions were suggested and a reduction in the number of sizes to eight, ranging from 10 to 150 hp., proposed. In the discussion, however, seven sizes were deemed sufficient, the range being from 6 to 175 hp., the lower limit being made 6, as motors of this size were frequently large enough for crane operation. The committee recommended the adoption of the 50-deg. rating for alternating-current motors for auxiliary service and to show what the motor would do on a 40-deg. rise, to also include the 40-deg. rating on the nameplate. For direct-current motors for auxiliary service other than the standard-mill type, the adoption of 40-deg. ratings for motors using class "A" insulation was recommended. Since a high percentage of motor troubles is due indirectly to bearings from the escape of oil, the sub-committee recommended the use of grease for the lubrication of sleeve bearings, or the use of ball or roller bearings where perhaps grease can be used to better advantage. Relative to the latter type of bearings, the committee recommended that the builders be approached with a view to working out a scheme whereby ball and roller bearings may be interchangeable among the various makes of motor and that a minimum number of sizes be selected to cover all motors.

Working plans of the subcommittee on illumination had been formulated with the ultimate point in view of studying each lighting problem common to the steel industry and offering a solution based on the use of the present available lighting units and accessories, these solutions to be compiled in such form as to be available for reference, with sufficient preliminary explanation to make the combination a handbook on steel-mill illumination. To meet with the problems of the industry, the committee offered its services during the year in a consulting capacity. As the first chapter of this handbook the committee offered the general nomenclature and standards of the illuminating engineering field as generally adopted and from a general survey of the industry presented information in tabular form covering present practice of 15 representative steel companies. A summary of this table including suggestions made by the committee was received with great interest. A point on which particular emphasis was placed was the importance of establishing a cleaning schedule for lamps, reflectors, walls and windows, in order that all light paid for in initial and running costs might be utilized to advantage rather than absorbed by dirty surfaces and that full use be made of all daylight available. The general physiological and psychological effects of cleanliness of all surroundings on a working force was in itself fully worth while in addition to a better lighting effect, a decrease in accidents, a reduction of wastage, an increase in production and a better product.

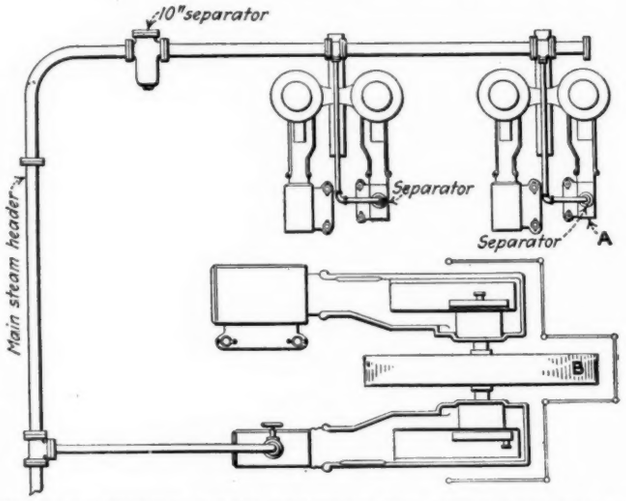
The Wilson Plant Cylinder-Head Explosion

From the inquest held into the cause of the cylinder-head explosion at the power plant of Wilson & Co., packers, Chicago, in which the watch engineer and an oiler lost their lives, as mentioned in the Sept. 13 issue of Power, more information is available on the accident. The engine, which was rated at 250 hp., was of the cross-compound type operating at 58 r.p.m. and driving directly a vertical ammonia compressor. The engine had been in continuous operation for three days when, at 7:45 p. m. on the Sunday preceding Labor Day, the head of the high-pressure cylinder blew off. It was later found that the cylinder head *A* was broken, the end of a built-up piston was shattered, the cylinder itself was broken off at the end where the metal was 2½ in. thick and the connecting rod was bent.

At the head of the engine and about 8 ft. distant was the flywheel *B* of another engine of about 800-hp. capacity. This engine was running at the time of the explosion. The two men were hurled into the flywheel, one man falling into the flywheel pit and the other being carried around the flywheel and then hurled across the station. Both men had their skulls fractured and necks broken as well as minor scalds due to hot oil and steam. Injuries due to the flywheel were considered by the coroner as the immediate cause of death, which was instantaneous.

As there was no evidence of scoring within the cylinder, water was decided to have been the cause of the explosion. The steam pressure was 150 lb. at the time of the failure. At the inquest it was brought out that the engine that failed had given trouble on previous occasions due to water entering the cylinder. Saturated steam is used and the steam line serving the engine that failed is a long line, 8 in. in diameter. To overcome water a 10-in. steam separator was installed several years ago in the main steam line in addition to the individual steam separators located above the throttle of each engine. All steam separators are piped directly to an individual receiver tank and then to the steam trap.

The engine that blew its cylinder head is at the end of the steam line, and it is probable that much of the water in the pipe would be blown along the straight run owing



PLAN OF ENGINE ROOM SHOWING RELATIVE LOCATIONS OF RUPTURED CYLINDER AND FLYWHEEL INTO WHICH MEN WERE HURLED

to the high velocity of the steam and lodge in the separator of this engine, passing the tee of the line to the engine between it and the boiler room.

The flywheel into which the two men were thrown was protected by a brass railing about three feet high. Such a rail offers protection against a man slipping on the engine-room floor, but is worthless should a man be forced against it, as happened when the cylinder head blew out. The jury recommended, therefore, that a metallic net or mesh guard be installed around all flywheels instead of the ornamental guards now used. They further recommend that extra precautions be taken to prevent water reaching the engine either by improved piping, closer feed-water regulation or in such other ways as may be found necessary.

Barrington Substation Destroyed

During the morning of Sept. 24 the Barrington, Ill., substation of the Public Service Company of Northern Illinois, serving nine towns, was completely demolished and one of the station operators lost his life. The accident took place during a thunder storm and it is reported that a bolt of lightning entered the plant. An explosion followed, the building crumbled into a mass of ruin and a fire started in the débris. Whether an electric or gas explosion took place has not been ascertained. An investigation is now going on.

The immediate necessity was to restore service and the company is to be congratulated upon the rapidity with which this was done. A large crew was assembled who worked through until a new substation was completed. Service was restored to the nine towns in just 35 hours and 35 minutes after the accident took place.

Washington News

News of the Power Commission—Coal Legislation—The Metric System Bill

By Paul Wooton
Washington Correspondent

A license for a period of fifty years has been issued by the Federal Power Commission to the Southern Sierras Power Co., of Riverside, Cal., covering a power project on the headwaters of Mill Creek in the Angeles National Forest. The project involves the diversion of water from High, Vivian, Falls, Alder and Lost Creeks. The water is to be dropped 2,047 ft. to a power house on Mill Creek. A storage reservoir, containing 100 acre-feet, would be formed on Falls Creek by the construction of an 80-ft. rock-fill dam.

A special condition of the license is that the construction of the entire project except the Falls Creek storage dam and reservoir, is to begin by Jan. 1, 1922, and be completed by June 30, 1923. The construction of the Falls Creek storage and dam reservoir is to begin by Jan. 1, 1925, and be completed by the end of that year. The licensee is also required to construct and maintain suitable stream-gaging stations.

The commission has granted a preliminary permit for two years to George C. Hazelet, of Cordoba, Alaska, for the development of a power project at the outlet of Silver Lake in the Chugach National Forest, in Alaska. The project involves the construction of a dam across Duck River and a pipe line to convey the water 7,000 ft. to a power house at the head of Galena Bay. The estimated power capacity of the project is 5,000 hp. It is to be used in the operation of a pulp mill. A condition of the license is that the permittee shall conclude arrangements with the Forest Service for the timber to be used in the operation of the proposed mill. He must also install and maintain a gage in the vicinity of the proposed dam to ascertain the discharge of the stream.

A preliminary permit for a period of fifteen months has been granted to the Unita Power and Light Co., of Myton, Utah, covering a power project on Spring branch and the Unita River, in Duchesne County, Utah. There are to be constructed diversion dams in each stream, a six-mile conduit, of which five miles is to be an open canal and one mile is to be of wood-stave pipe penstock, and a power house in which the permittee proposes to install equipment of 4,800 kw. capacity.

An extension for one year, or until Oct. 1, 1922, has been granted by the commission to the United Mills Co., of Hickory, N. C. The preliminary permit covers a power project on Harpers Creek, Caldwell County, N. C. The extension is made so that the permittee may determine intelligently whether or not the natural flow of the stream is of sufficient volume to justify its development.

Rules and regulations for the establishment and maintenance of a system of accounts for licenses under the Water-power Act will be discussed before O. C. Merrill, the executive secretary of the Power Commission, at a public hearing in Washington, Oct. 17. On that occasion an opportunity to be heard will be given anyone desiring to offer criticisms or suggestions concerning the proposed accounting rules and regulations.

If a satisfactory arrangement can be made, the commission will co-operate with the State of California in the study of the water-power resources of that state. The executive secretary was authorized to expend $15,000 to cover the expenses of the commission's participation in the work, and the State of California has appropriated $200,000 for the study.

Status of the Two Coal Bills

Statements that the bill of Representative Newton, of Minnesota, will be given consideration in the near future could not be substantiated at the Committee on Interstate and Foreign Commerce, to which the bill was referred. The Newton bill is a composite of the Calder and the La Follette bills, with certain minor changes of Mr. Newton's own making. The measure is drastically regulatory, and members of the committee expressed the opinion that it is not being seriously considered. Since Mr. Newton is a member of the committee, however, he is in a position to precipitate discussion of the bill at any meeting.

Senator Frelinghuysen returned to Washington after the Congressional recess without having determined on any change in his policy as to coal legislation. He expects to watch developments closely and be in readiness to call up his coal stabilization bill at any time likely to be opportune for its passage or when its discussion might tend to correct any trend of the coal situation against the public interest.

Metric Arguments To Be Heard

Hearings on Senator Ladd's metric system bill are expected to begin about the middle of October. The fixing of a definite date is awaiting the return of Senator McNary of Oregon, who as chairman of a sub-committee of the Committee on Manufactures will conduct the taking of testimony. Senator Ladd states that it is not the intention at this time to conduct extended hearings. An opportunity will be given to the proponents and opponents of the measure to make a concise presentation of the major points of their respective contentions. These preliminary statements will comprise a single record that is to be distributed widely with the idea of acquainting the public with the principal reasons for and against the adoption of the metric system as the single standard of weights and measures for the United States.

A, Synchronous-Induction Motor*

Raising the power factor is one of the logical ways of increasing the output of central stations, decreasing the cost of power and bettering service generally. Any means of accomplishing this in a distribution system should therefore be of interest to all central-station engineers, particularly if it is likely to popularize the synchronous motor as a substitute for the induction motor.

A motor combining the characteristics of induction and synchronous motors has been manufactured by the Oerlikon

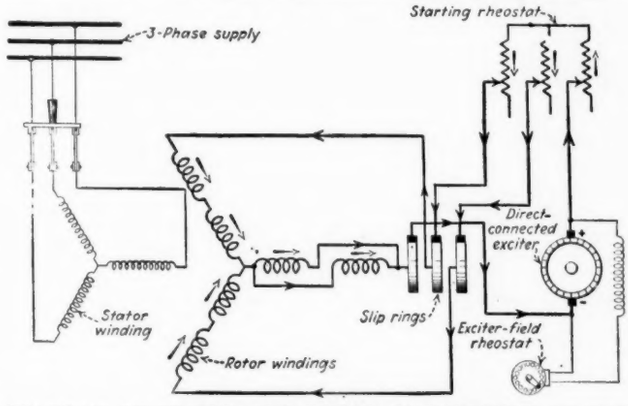


DIAGRAM OF STATOR AND ROTOR CONNECTIONS OF THE SYNCHRONOUS-INDUCTION MOTOR

Works in Switzerland for the last two years. It is in nearly all respects an induction motor of the wound-rotor type, with the addition of a direct-current exciter mounted on the end of the shaft. The only difference in the internal connections is illustrated in the diagram. The rotor is wound three-phase-star with each phase in two equal windings. In two of the phases these windings are in series and in the third in parallel. The exciter is in series with the latter, between the brush and the starting rheostat.

The machine starts up as a plain induction motor with resistance control, therefore with a high starting torque the stator being connected directly to the line. As it gains speed, the exciter gradually builds up and sends direct current through the rotor windings in the direction indicated by the arrows. This direct current is superimposed upon the three-phase currents in the windings and induces a field

*Abstracted from *Le Genie Civil*, August 13, 1921.

that is fixed in respect to the rotor, therefore revolving with respect to the stator. When the motor approaches synchronism, the rotor field due to the direct-current excitation lags behind the stator field only a few revolutions per minute, and the reaction between the two easily pulls the rotor up to synchronous speed. From that moment the machine is in every respect a synchronous motor and may be made to draw leading or lagging wattless current or to operate at 100 per cent power factor, as desired, by adjusting the exciter-field rheostat.

An interesting feature of the machine is that, if a sudden overload or change of frequency should pull it out of step, it will not shut down or blow the breakers as would an ordinary synchronous motor, but will automatically revert to induction-motor characteristics, until the load has decreased sufficiently so that it can once more pull into step. A certain amount of disturbance will be caused in the stator circuit when the motor drops out of step, but not enough to seriously interfere with the operation of any other apparatus on the line, particularly as this should occur only in exceptional cases.

The motor shares with the synchronous motor the disadvantage of requiring an exciter, and therefore being of considerably higher first cost than an induction motor. It has over the synchronous machine the advantage of better starting characteristics and of requiring no synchronizing.

One of the most interesting applications of this machine will probably be as a generator to replace induction generators in automatic water-power plants. Induction generators are installed in such plants because they require practically no attention. Their great disadvantage is the heavy lagging magnetizing current drawn from the system. Synchronous generators, on the other hand, must be synchronized, and cannot be relied upon to stay in step on variable loads. They cannot, therefore, be installed in sites of difficult access. The synchronous induction generator will need no more attention than the induction generator, and, instead of lowering the power factor of the system, may be adjusted to draw leading current and so compensate for the low power factor of other apparatus on the line.

Accident to Ammonia Compressor

The East Seventieth Street ice plant of the Knickerbocker Ice Co., New York City, met with an accident on the night of Sept. 16 which resulted, among other things, in the loss of almost all the charge of ammonia in this 300-ton plant.

The plant contains two Wolf horizontal double-acting ammonia compressors, each of which is direct connected to a tandem compound Nagle Corliss engine. The compressor

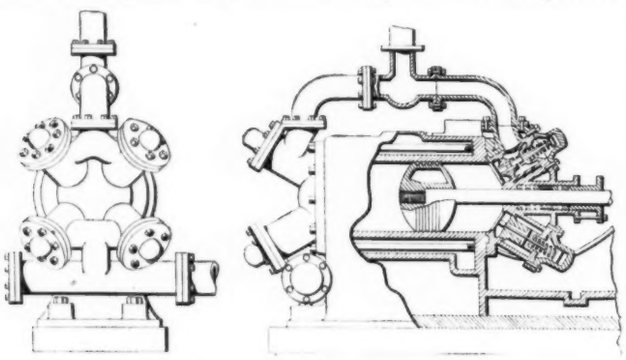


FIG. 1. WOLF COMPRESSOR

cylinders are similar to that shown in Fig. 1. The suction vapor enters each cylinder head at the top through poppet valves, while the discharge poppet valves are in the lower half of the heads.

The construction of the suction valves is along the lines shown in Fig. 2. It will be noted that a safety collar is placed on the valve stem to prevent the stem from dropping into the cylinder if broken. On the night in question the engineer was on the floor above the engine room when one of the suction-valve stems broke below the safety collar. The valve dropped into the cylinder and the piston striking the valve caused the cylinder head to break into a number of pieces. This allowed the ammonia vapor from the evaporating coils to flow out through the broken suction connection. The discharge line was equipped with a non-return valve which, closing, prevented the escape of the liquid and vapor in the high-pressure side. The engineer on discovering the state of affairs endeavored to stop the engine and to close the suction valve. The strong ammonia

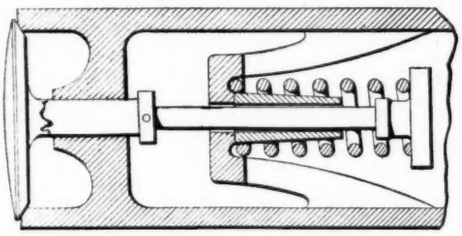


FIG. 2. BROKEN SUCTION VALVE

fumes drove him out, although he was able to close all the expansion valves, which isolated the high-pressure side and allowed only the ammonia in the coils to escape.

The fumes of the ton or more of ammonia filled the entire neighborhood and four or five thousand people in a territory around the plant measuring about two by four blocks were driven out of the district.

The fire department, in responding to the fire, connected the hose lines to the high pressure diffuser and practically emptied the condensers and receivers of their charge of liquid ammonia. The total loss of ammonia was probably 4,000 lb., and, as indicated, half of this was lost through the mistake of the fire department.

The unusually large loss of ammonia in such a crowded district without any serious injury to anyone answers all questions as to the actual danger of having an ammonia plant located in cities. On the other hand, it does emphasize the advantage to be secured by a safety system whereby a local defect in any part of the refrigerating plant could be isolated. It would also appear highly desirable to have more complete instructions issued as to the best methods to be followed by the plant force and the fire department when accidents occur.

More States Approve National Board Stamp

Announcement has been received from the secretary-treasurer of the National Board of Boiler and Pressure Vessel Inspectors that nine states have now agreed to accept the board's stamp on boilers as of equal authority with their own stamps. These nine states are: California, Indiana, New Jersey, New York, Oklahoma, Ohio, Oregon, Rhode Island and Wisconsin.

This announcement indicates that the board is meeting with success in its efforts to standardize boiler inspection throughout the country. There remain about eight states where the A. S. M. E. Code is in effect that have not approved the National Board's stamps, and it is understood that efforts are being made to bring them to take the necessary action, so that the work of the board may be made more fully effective.

A $10,000,000 power development project has been arranged for at Great Falls on the Winnipeg River in Canada. Work has already begun, and it is expected that the plant will be completed in 1927. The capacity will be 168,000 hp. The project is being undertaken by the Manitoba Power Co., Ltd., which is taking over the assets of the Winnipeg River Power Co.

The explosion of a high-pressure heating boiler recently in the plant of the West Virginia Pulp and Paper Co., at Mechanicville N. Y., killed five men and hurled the roof of the building 100 ft. away. The boiler carried 125 lb. of steam and was used in the process of cooking wood into pulp.

New Publications

MECHANICS — A TEXT-BOOK FOR ENGINEERS. By James E. Boyd, M. S., Professor of Mechanics, Ohio State University. First edition. Published by McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York City, 1921. Cloth; 6 x 9 in.; 411 pages, 340 illustrations. Price, $3.50 postpaid.

The purpose of this book is to give a working knowledge of the principles of mechanics and to supply a foundation upon which intelligent study of Strength of Materials, Stresses and Structures, Machine Design, and other courses of a more technical nature may rest. Although considerable use is made of mathematics as a convenient tool for the determination and expression of quantitative relations, the author has taken considerable pains to make certain that the student never loses sight of the physical meaning of the ideas involved. The illustrations are plentiful and unusually good and many of them are notably original. While this is a text-book of the principles of mechanics rather than their applications, the problems chosen are closely related to those found in practical work so that the student who masters this book should find no difficulty in understanding the applications. This is primarily a text-book for engineering schools, but should prove of value to those home students who are moderately well grounded in mathematics and to engineers who wish to keep on hand for reference purposes a clear and complete text-book of mechanics.

PETROLEUM LAWS

The latest available information on petroleum laws has been compiled in a 5½ x 9 in., 645-page pamphlet by the United States Bureau of Mines through co-operation with the State Department. The book gives the laws regulating leases and concessions and the explorations for and exploiting of petroleum in the various States of this country and Canada, Mexico, Central America and South America. Single copies may be obtained free of charge from the Bureau of Mines until the first edition is exhausted, after which the book may be bought from the Superintendent of Documents at the Government Printing Office, Washington, D. C., for 40 cents.

Obituary

James Craig Stewart, senior partner in the Stewart Boiler Works of Worcester, Mass., died Sept. 22, in the Peter Bent Brigham Hospital, Boston, shortly after he had been afflicted with a shock on a short business trip from New York to Boston. He was born in 1857 in St. John, N. B., the son of Charles Stewart, a native of Scotland who had been an apprentice in the boiler works of the famous John Stevenson. His father left Scotland in 1852 and built up a boiler business, to which James was admitted in 1878 under the name of Charles Stewart & Son. Two of his brothers, Charles M. and John C., later joined the firm. Mr. Stewart was a Mason and an Odd Fellow and was a member of the Worcester Automobile Club.

Henry J. Kinman, manager of the Cleveland plant of the Chicago Pneumatic Tool Co., died in Cleveland on Sept. 7. He was born in Haarlem, Holland, in 1863, and emigrated to America with his parents, settling in Chicago in 1870. He served his time with the Adams-Westlake Co. and other manufacturing concerns in Chicago and the far West. His one ambition was to engage in business for himself, and the start was made by converting the basement of his home on Nineteenth Street, Chicago, into a small machine shop, working days as a machinist for hire and working evenings for himself. He designed and, in collaboration with his brother, built the first practical portable piston air drill, known as the Little Giant. Soon after engaging in the manufacture of air drills, he joined E. N. Hurley in the formation of the Standard Pneumatic Tool Co. in 1898. He became associated with the Chicago Pneumatic Tool Co. in the consolidation of pneumatic tool interests in 1901, when he became manager of the Cleveland plant of the company and remained in active charge until his death.

Society Affairs

The Providence Engineering Society's management section will hold a joint meeting with the Providence section of the American Society of Mechanical Engineers Oct. 4, at which "Safety Appliances" will be discussed by Franklin D. Warren, of the American Mutual Liability Insurance Co. Moving pictures of accidents will be shown, and the election of officers for both sections will be held.

Business Items

The Goetze Gasket and Packing Co. has opened a Philadelphia branch in the Drexel Building, 5th and Chestnut Sts., under the management of the Sheffler-Gross Co.

The M. J. Dougherty Co., 25th and Washington Aves., Philadelphia, Pa., has announced the appointment to its sales force of Earl F. Hemple, M. E., formerly chief engineer of the Edison Portland Cement Co., of Stewartsville, N. J.

Trade Catalogs

The Taylor Machine Co., 25 East Jackson Boulevard, Chicago, Ill., is distributing a new bulletin on its stationary and marine type, heavy-duty, two- or four-stroke-cycle, semi-Diesel oil engines, which are built in sizes up to 6,000 hp.

The Elliott Co., Jeannette, Pa., has prepared two new catalogs describing the Elliott deaëration process for removing air and dissolved gases from water to prevent corrosion. One, Bulletin N-1, deals with the application of the process to power-plant work, while the other, Bulletin N-2, treats of application to domestic hot-water service.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	Sept. 20, 1921	Sept. 27, 1921
Pool 1,	New York	$3.25	$3.00@3.50
Pocahontas,	Columbus	2.75	2.50@2.75
Clearfield,	Boston	1.95	1.65@2.10
Somerset,	Boston	1.75	1.45@2.10
Pittsburgh,	Pittsburgh	2.20	2.20@2.25
Kanawha,	Columbus	2.15	1.75@2.25
Hocking,	Columbus	2.15	2.00@2.75
Pittsburgh No. 8	Cleveland	2.15	2.00@2.15
Franklin, Ill.,	Chicago	2.90	2.40@3.50
Central, Ill.,	Chicago	2.40	2.00@2.75
Ind. 4th Vein,	Chicago	2.40	2.00@2.75
Standard	St. Louis	1.95	1.85@2.00
West Ky.,	Louisville	2.25	2.00@2.50
Big Seam,	Birmingham	2.15	2.00@2.25
S. E. Ky.,	Louisville	2.15	2.00@2.40

New York—On Sept. 27, Port Arthur light oil, 22@25 deg. Baumé, 4c. per gal. 30@35 deg., 5c. per gal. f.o.b. Bayonne, N. J.

Chicago—Sept. 10, for 24@28 deg. Baumé, 40@45c. per bbl.; 32@36 deg. 1¼@1½c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—On Sept. 19, f.o.b. refinery: Pennsylvania, 36@40 deg., 3¼ to 4c.; Oklahoma, 24@30 deg., 50@55c. per bbl.; gas oil, 32@34 deg., 1¼c. per gal., 36@38 deg., 1⅝c. 38@40 deg., 1¾c.

St. Louis—Sept. 24, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 45c. per bbl.; 26@28c. deg., 55c.; 28@30 deg., 60c.; 32@34 deg. 1¼c. per gal.

Philadelphia—On Sept. 26, 26@28 deg. Baumé, Oklahoma, 45c. per bbl.; 30@34 deg., Oklahoma (group 3) 70c. per bbl.; 16@20 deg. Seaboard, 3c. per gal.

Cincinnati—Sept. 19, for 22@28 deg. Baumé, 3c.; Diesel, 26@30 deg., 3¾c. per gal.

Cleveland—Sept. 19, for 22@28 deg. Baumé, 5c. per gal.

New Construction

PROPOSED WORK

Mass., Springfield—Comrs. of city Property, Administration Bldg., A. H. Cote, Chn., will receive bids until Oct. 13 for a 4 story junior high school on State St. About $800,000. H. L. Sprague, 310 Main St., Archt.

R. I., Providence—The city, Public Bldgs. Dept., City Hall Prov., will receive bids until about Oct. 11 for a 3 story, 180 x 300 ft. high school on Summer St. About $1,250,000. Hoppin & Field, 32 Westminster St., Archt. W. E. Hartwell, City Hall Prov., Engr Noted Sept. 6.

N. Y., Buffalo—The Bd. Educ., Telephone Bldg., received bids for heating and ventilating systems to be installed in schools (A) 60, Ontario and Saratoga Sts; (B) 21, Hertel and Camden Aves.; (C) 1, Porter and Niagara Sts.; (D) 9, Poplar and Doat Sts.; (E) Primary school 21, Amherst St. at Parklake Ave.; (F) 7, New Berry St. and Lang Ave.; (G) 9, Sherman, Stanton, and Lovejoy Sts.; (H) 11, Bailey Ave., Regent and Moreland Sts.; (I) 12, Lorraine Ave., near Abbott Rd.; (J) 2, Hertel and Shoshone Sts.; (K) 6, Northampton and Fougerson Sts.; (L) 8, Elmwood Ave. and Tracy St. From the Power Efficiency Co., White Bldg., (A), $93,200; (B), $59,280; (C), $77,886; (D), $77,086; (E), $16,834. The Sodeman Heat & Power Co., 2306 Morgan St., St. Louis, Mo., (F), (G), (H), (I), $134,787 each, and (J), (K), (L), $136,137 each.

N. Y., New York—The Equitable Life Assurance Co., 120 Bway., plans to build an office building on 7th Ave. between 31st and 32d Sts. About $1,000,000.

N. Y., New York—M. J. Kramer, 309 5th Ave., is having plans prepared for a 6 story apartment on Hamilton Place. About $750,000. H. J. Krapp, 116 East 16th St., Archt. and Engr.

N. Y., New York—W. A. White & Sons, 46 Cedar St., are receiving bids for the installation of oil-burning equipment in large office building.

N. Y., Wilson—The Niagara County Preserving Corp. is in the market for a 100 hp. horizontal tubular boiler complete with capacity of 100 lb. pressure test.

Va., Portsmouth—Planters Mfg. Co., Inc., manufacturers of fruit and vegetable crates, etc., W. W. Hargroves, Genl. Mgr., is in the market for a 100 ft. gravity conveyor, a 250 hp. electric generator alternating or direct current, one boiler, 150 to 200 hp. with 125 steam pressure, and other machinery.

N. J., Atlantic City—H. R. Kline, Archt., 1612 South 4th St., Philadelphia, Pa., will receive bids until Oct. 15 for a 5 story, 50 x 100 ft. hotel at 11 South New Jersey Ave. for Mrs. K. O. Donnell. About $250,000.

N. J., Salem—W. B. Dunn, City Recorder, will receive bids until Oct. 24 for furnishing material and labor for the installation of high service pumping machinery in one 3,000,000 gal. unit and low service pumping machinery in one 3,000,000 gal. unit. Concrete foundations to be furnished and installed by the city. W. H. Boardman, 426 Walnut St., Phila., Pa., Engr.

N. J., West Wildwood (Wildwood P. O.)—The Borough received low bid for sewage treatment plant and sewers from Craigthorn & Nickerson, Wildwood, $32,000. Two centrifugal pumps to pump 60,000 gal. of water will be installed.

Pa., Bedford Springs—The Bedford Springs Hotel Co. is having plans prepared for an 8 story hotel. Cost between $400,000 and $500,000. Rutan, Russell & Wood, Century Bldg., Pittsburgh, Archts.

Pa., Harrisburg—The Dept. of Public Safety, Dr. S. F. Hassler, Supt., will receive bids until Oct. 13 for Contract A—Enlargement of filtration plant, including the installation of 8 new filters, a filter building, a pure water reservoir, sedimentation and coagulation basins and a 15 million gal. low lift pumping unit with boiler and accessories. Contract B—Improvements to pumping station, including the installation of 2 fifteen-million gal. high lift centrifugal pumps with boilers and accessories and a boiler house. J. H. Fuertes, 140 Nassau St., New York City, Engr.

Pa., Philadelphia—Hoffman & Henon Co., Archts., Finance Bldg., will receive bids until Oct. 15 for a 1 story, 110 x 180 ft. theatre at 1825-33 Market St. About $500,000. Owner's name withheld.

Pa., Pittsburgh—The Bd. Educ. received lowest bid for a heating and ventilating system in the Greenfield and Perry elemen-

tary schools from S. F. Higgins Co., Pittsburgh, $41,236 and $41,366 respectively; in the Westinghouse high school from B. O'Neil Co., Pittsburgh, $48,770.

Pa., Reading—The city is having plans prepared for a water pumping station, including the installation of pumps and equipment. About $150,000. L. T. Klander, Penna. Bldg., Philadelphia, Engr.

D. C., Washington—The Dist. Comrs. will receive bids until Oct. 20 for the construction of a 3 story Eastern high school, including the mechanical equipment. About $700,000.

D. C., Washington—The Monastery of the Visitation is having plans prepared for a monastery. About $300,000. G. I. Lovatt, 420 Walnut St., Phila., Pa., Archt.

D. C., Washington—Wise Bros., 3206 N St. N. W., are having plans prepared for an addition to dairy plant, including refrigerating plant, etc. About $75,000. A. P. Clark, Jr., 816 14th St., Archt.

W. Va., Elkins—H. G. Kump, Mayor, will receive bids until Oct. 7 for improvements to water-works system, including pump house, filter bldg., sedimentation basin, and intake for 2,000,000 gal. plant, filter equipment and piping for four 500,000 gal. units, addition to reservoir of 1,000,000 gal. and two 2,000,000 gal. high duty pumps and three 2,000,000 gal. low duty pumps with motors, etc., also laying mains and supplying 150 tons cast iron pipe and specials, valves and hydrants. B. Kress, 8 and 9 Fair Bldg., Practicing Municipal Engr.

Miss., Greenwood — P. B. Dennis, City Clk., will receive bids until Oct. 18 for the construction of storm sewers and for furnishing and installing one 36 in. centrifugal pump with 300 hp. electric motor direct connected, complete with vacuum priming pump and motor, also for furnishing one 40 and one 20 hp. electric motor. F. T. Walker, City Engr.

Miss., Starksville—The State Bond Improvement Comn., T. C. Link, Supervising Archt., and Dir. Public Wks., Jackson, will receive bids until Oct. 15 for furnishing:

Two 200-kw. ac. generators, direct connected to steam engines or turbines.

One 2 stage air compressor of 700 cu.ft. displacement, direct connected to synchronous motor.

Two centrifugal pumps of 600 gals. per min. cap. against 150 ft. head, direct connected to 3 phase induction motors.

One centrifugal pump of 50 gals. per min. cap. against 50 ft. head, direct connected to 3 phase induction motor.

One single acting triplex plunge feed water pump of 40 gal. per min. cap., geared to 3 phase induction motor.

One duplex outside-end-packed plunger, pot valve feed water pump of 70 gal. per min. cap. at 30 strokes per min.

Two 8 in. and 10 in. x 12 in. vacuum pumps for heating system.

One ice making plant, complete except cans and distilling system, with capacity of 7½ tons of ice per 24 hrs.

One cast iron stack type open feed water heater of approximately 1,200 boiler hp. cap.

One closed type hot water supply heater, cap. 2,500 gal. per hr., and storage space of approximately 900 gal.

One 10 panel black marine finish slate switchboard.

One radial brick or reinforced concrete chimney, 7 ft. inside dia. at top and 150 ft. high above top of foundation; foundation not included.

Tenn., Nashville—The Peabody Teachers College, Peabody Campus, is having plans prepared for two dormitory buildings on the campus. About $150,000 each. H. C. Hibbs, 4th and 1st Natl. Bank Bldg., Archt.

Tenn., Memphis—R. Brinkley Snowden, 1397 Center Ave., is receiving bids for a 21 story, 75 x 75 ft. office building including a steam heating system on Court and Maiden Lane. About $1,000,000. Hanker & Cairns, Scimitar Bldg., Archts.

O., Ashtabula—The City received bids for a 1 story, 80 x 80 ft. power plant from the Service Constr. Co., 6110 Euclid Ave., Cleveland, $62,480; and Hughes, Foulkrod Co., Oliver Bldg., Pittsburgh, Pa., $66,300.

O., Columbus—The American Insurance Union, 44-50 West Broad St., has had plans prepared for a 25 story, 123 x 187 ft. building on East Broad St. Cost between $3,000,000 and $3,500,000. F. L. Packard, New Hayden Bldg., Archt.

Mich., Ann Arbor — St. Mary's Chapel, Rev. M. P. Rourke, is having plans prepared for a 4 story dormitory building, also assembly hall and restaurant, etc., including a steam heating system on Jefferson and Maynard Sts. About $250,000. Architect not announced.

Mich., Ann Arbor—The University Land Co., c/o S. E. Remey, Archt., 503 Whitney Bldg., Detroit, plans to build a 4 story, 60 x 185 ft. dormitory and hotel building, including a steam heating plant, on Huron St. About $350,000.

Ill., Chicago — Plotke & Grosby, 2532 North Clark St., is having plans prepared for five apartment buildings, including a steam heating system, each 3 story, 110 x 175 ft., on Sheridan Rd. and Estes Ave. About $250,000. A. V. Teisen, 4804 North Kodzie Ave., Archt.

Ill., Granite City — The Cabaret Range Co. is having plans prepared for a range factory consisting of 4 buildings, two 70 x 300, one 70 x 100 and one 24 x 70 ft. About $300,000. C. Pauley & Son, 19th and C Sts., Archts. Noted Sept. 27.

Ill., Harrisburg—The Bd. Educ., c/o G. Davenport, will receive bids until Oct. 10 for a 2 story, 140 x 140 ft. school. About $300,000. A. L. Barnes, 1329 Birchwood Ave., Chicago, Archt. Noted April 19.

Wis., Milwaukee—P. Braman, Comr. of Public Wks., City Hall, will receive bids until Oct. 24 for furnishing and erecting pumping machinery, including one 25,000,000 and two 22,000,000 gal. vertical triple expansion crank and flywheel pumping engines, in the Riverside Pumping Station. About $210,000.

Kan., Emporia—C. K. Williams representing stock company, is having plans prepared for a 7 story hotel, including a steam heating system. About $300,000. J. E. Eberson, 64 East Van Buren St., Chicago, Ill., Archt.

Kan., Wichita—G. H. Siedhoff, 1st and Market Sts., is having plans prepared for a 6 story, 80 x 260 ft. hotel including a steam heating system on Douglas and Waco Aves. About $500,000. E. Forsblom, Sedgwick Bldg., Archt.

Ark., Fort Smith—The Ft. Smith Light and Traction Co., 3d and Garrison Aves., D. C. Green, Genl. Mgr., is having plans prepared for an addition to electric light and power plant on 9th and A Sts. to increase capacity 5,000 kw. Private plans.

Tex., Cameron—The city plans to vote $250,000 bonds for sewage disposal plant, water-works plant and an electric light and power plant. Engineering Service Co., 606 Sumpter Bldg., Dallas, Engrs.

Okla., Oklahoma City—J. L. Dickey, representing stock company, 1108 West 33rd St., is having plans prepared for a 7 story, 150 x 200 ft. apartment including a steam heating system. About $500,000. M. Jayne, 1104 1st Natl. Bank, Archt.

Okla., Oklahoma City — Hawk & Parr, Archts., Magnolia Bldg., will receive bids until Oct. 4 for a 6 story, 125 x 140 ft. clubhouse, including a steam heating system, for the Oklahoma Club, c/o J. Shartel. About $350,000.

Okla., Pawhuska—The city, c/o W. I. Broaddus, Clk., is having plans prepared for water-works improvements, including a pumping station, reservoir, laying new mains, etc. About $177,000. H. G. Olmsted & Co., Trademans Bk Bldg., Engr.

Okla., Pryor Creek—The city, c/o H. E. Rogers, Clk., will soon award the contract for waterworks improvements, including 6 miles transmission lines, basin pipe, pumps, etc. About $35,000. V. V. Long & Co., Colcord Bldg., Oklahoma City, Engrs.

Okla., Sayre—The city, c/o W. E. Sinnonds, Clk., will receive bids until Oct. 25 for an addition to electric light plant, including equipment. About $28,500. V. V. Long & Co., Colcord Bldg., Oklahoma City, Engrs.

Okla., Tulsa — The Cosden Refining Co., West Tulsa St., plans to build an addition to steam power plant on West Tulsa St. About $100,000.

Que., Montreal—The city, A. E. Doucat, Dir of Public Wks., L. O. Prow, Purch. Agt., is in the market for electrical equipment for new pumping station. About $75,000.

Ont., Brigden — The Township Council, W. J. Brownlee, is having surveys made for a hydro-electric system. About $30,000. V. A. Beacock, 190 University Ave., Toronto, Engr.

Ont., Camlachie—The Township Council, Dr. Brown, is having plans prepared for an electric lighting and power distribution system. About $75,000. E. D. Lawler, 190 University Ave., Toronto, Engr.

Ont., Crediton—The Council, C. Zwicker, is having surveys made for a hydro lighting and power distribution system. About $33,000. J. N. Wilson, 190 University Ave., Toronto, Engr.

Ont., Dresden—Camden Township, J. Crydermann, Thamesville, chn., plans to build a hydro-electric system. E. R. Fowler, 190 University Ave., Toronto, Engr.

Ont., Georgetown—The town plans to build an addition to the pumphouse and extensions to the waterworks. About $60,000.

Ont., Leaside—The Durant Motors, Inc., Toronto, plans to build a 8 story, 130 x 600 ft., factory, including a steam heating system, here. About $800,000.

Ont., Ottawa—The Ottawa Collegiate Bd., G. Bowie, Chn., 7 Monkland Ave., is having plans prepared for a 3 story collegiate, including a vacuum steam heating with mechanical ventilating system, on 1st Ave. About $700,000. J. A. Ewart, Jackson Bldg., Archt.

CONTRACTS AWARDED

N. Y., Brooklyn — The Bd. Educ., 500 Park Ave., New York City, has awarded the contract for P. S. 136, on 4th Ave. between 40th and 41st Sts., to Frymier & Hanna, 25 West 45th St., New York City. $419,300.

N. Y., Brooklyn—M. Halperin, 7 Bond St., will build a 6 story, 100 x 100 ft. apartment on 4th St. and 8th Ave. About $400,000. C. Ifanger & Son, 2634 Atlantic Ave., Archt. and Engr. Owner will build by day labor.

N. Y., New York—S. W. Straus & Co., 150 Bway., has awarded the contract for a 50 x 100 ft. apartment at 34 East 51st St. to F. F. French, Madison Ave. and 4th St. About $600,000.

N. Y., Perrysburg—The City of Buffalo, Municipal Bldg., Buffalo, has awarded the contract for a hospital here to J. W. Cowper Co., Fidelity Bldg., Buffalo, $689,830. Noted Sept. 27.

N. J., Hackensack—The Hackensack Hospital Mgrs. have awarded the contract for a hospital to the White Constr. Co., Hackensack. About $700,000.

Pa., McKeesport—The McKeesport Hospital has awarded the contract for a 3 and 4 story hospital building, including nurses' home, dormitory building and power plant, to E. H. Cannon, Rubin Bldg. About $250,000. Noted Sept. 6.

Pa., Reading—The Rajah Theater Corp., c/o E. C. Horn & Sons, Archts., 1476 Bway., New York City, will build a temple and theater building. About $400,000. Work will be done by separate contracts.

D. C., Washington—The Bureau of Yards and Docks, Navy Dept., has awarded the contract for a distribution system at the Naval Hospital to J. W. Danforth Co., 72 Ellicott St., Buffalo, N. Y., $25,242. Spec. 4510. Noted Sept. 27.

Miss., Magee — T. C. Link, Supervising Archt., Dir. Pub. Wks., P. O. Box 636, Jackson, has awarded the contract for a tuberculosis sanatorium to consist of several buildings, including a power house, to Smith Co., Industrial Bldg., Birmingham, Ala., $544,030. Noted July 19.

O., Youngstown—The Distilled Water Ice Co., 523 West Federal St., has awarded the contract for a 1 story, 70 x 160 ft. ice plant on Federal St. to Heller Bros., Furnace St. About $100,000.

Ind., Belleville—The United States Army, Quartermaster General, Construction Div., has awarded the contract for steel hangar, including boiler house, gas holder, etc., at Scott Field to W. M. Southerland Bldg. and Contracting Co., Syndicate Trust Bldg., St. Louis, Mo., $1,043,492.

Ill., Chicago — Alexander Flower, c/o Roosevelt State Bank, 35th and Grand Blvd., has awarded the contract for a 3 story, 100 x 205 ft. theatre and store building on 35th and Grand Blvd. to E. M. Bertha, 11 South La Salle St. About $400,000. A steam heating system will be installed. Noted July 19.

Ill., Chicago—The Treasury Dept., J. A. Wetmore, Supervsing Archt., Wash., D. C., has awarded the contract for the installation of a deep well and pumping plant in the Broadview Hospital to F. M. Gray, 105 Wells Bldg., Milwaukee, Wis., $37,000.

Wis., Milwaukee—The Marquette University, 1115 Grand Ave., has awarded the contract for a 1 story, 58 x 68 ft. boiler house on 16th St. to W. W. Oeflein, 86 Michigan St. About $25,000. Noted July 19.

Kan., Quinter—The city, c/o H. C. Porter, Clk., has awarded the contract for an addition to municipal power plant to the Challenger Co., 1402 West 12th St., Kansas City, $33,770. Noted Sept. 6.

S. D., Mitchell — St. Joseph's Hospital, Rev. J. M. Brady, Chn. Bldg. Comn., has awarded the contract for a 3 story, 66 x 145 ft. hospital to W. D. Lovell, 1415 8th St. S. E., Minneapolis, Minn. About $170,000. A steam heating system will be installed. Noted May 17.

Cal., Los Angeles—Keller & Comey Co., c/o G. W. Eldredge, Archt., 226 Pacific Finance Bldg., has awarded the contract for a 2 story, 125 x 240 ft. ice cream plant on San Pedro St. to W. A. Heitman Co., Merritt Bldg. About $600,000. Ice making machinery, conveyors, etc., will be installed.